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Mining and Metallurgical Section.

(Stated Meeting held Thursday, May 9th, 1907.)

Extract of Report on the Methods Used to Avoid Piping in Steel Ingots, as Applied in the Hungarian Government Steel Foundries at Diosgyör.

BY ENGINEER ALBERT OBHOLZER.

(READ BY TITLE.)

The modern development of the machinery of rolling mills has brought about with it higher requirements in regard to the quality of the raw material.

Various means have been employed to remove the so-called "piping" in ingots, by various shapes of ingot molds or by placing the ingot under pressure before the steel has set. The most successful of these methods has been that invented by Mr. Harmet, Director of the steel works in San Etienne, which, however, requires rather elaborate machinery.

A method proceeding on entirely different lines is the Anti-Piping Thermit method, which has shown, in our practice, considerable advantages over the Harmet process.

A number of experiments were made at the Diosgyör works, in the casting of Martin Steel ingots. For the purpose of comparison, two blocks were poured out of the same charge—one with, and the other without an addition of Anti-Piping Thermit. These ingots were then cut longitudinally with a saw, up to a one-third of their axis, and the middle of the ingot was then cracked by means of wedges.

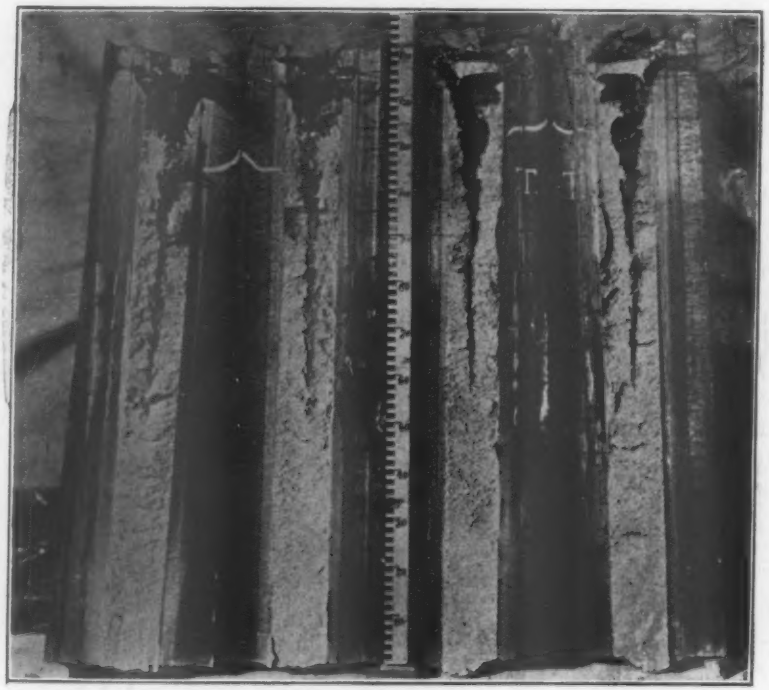

Fig. 1.

The blocks marked "T" on the accompanying cut, are those cast with the addition of Anti-Piping Thermit.

For the purpose of these tests, the usual practice of making a second pour a little after the first, was not followed, either in the ingots with or without Anti-Piping Thermit. Figures 1 and 2 show the ingots poured in this manner, cut on both sides and broken in the middle.

Cut No. 1 shows ingots cast in the so-called "Goliath" block

molds, without feeding heads, and those in cut 2, cast in octangular molds, with feeding head. The feeding head consisted of refractory brick walls, which were heated to a red heat.

It will be observed that the piping in the ingots treated with Anti-Piping Thermit is not so extensive and does not reach down so far as in those without Thermit. The exact measurements are as follows:

FIGURE 1, WITHOUT THERMIT.

Piping visible to the naked eye	808	m.m. in length.
" " with the microscope	34	" "
Total	842	m.m.

INGOT TREATED WITH THERMIT.
Marked "T. T."

Piping visible to the naked eye	760	m.m.
" " with the microscope	20	"
Total	780	m.m.

PIPING IN INGOTS, FIGURE 2.
POURED INTO OCTANGULAR MOLDS WITH FEEDING HEAD.
INGOTS WITHOUT THERMIT.

Piping visible to the naked eye	1060	m.m.
" " with the microscope	10	"
Total	1070	m.m.

INGOTS CAST WITH THERMIT, SAME CONDITIONS.

Piping visible to the naked eye	930	m.m.
" " with the microscope	75	"
Total	1005	m.m.

Figures 3 and 4 represent ingots cast according to regular practice, with feeding head, which, after the pour, are kept hot by being covered with charcoal or other material.

In casting ingot shown in Fig. 3, 5½ lbs. of Thermit were applied and the piping in the upper part of the ingot is practically nil. The ingot shows a homogenous grain in its entire fracture.

Figure 4 represents octangular blocks cast without Anti-Piping Thermit, with feeding head as described above.

The fracture of the heavier ingot—four tons—is without flaw, except the piping in the upper part of the head. (See explanation below.) This piping extends from the upper part of the ingot 300 m.m.; from the lowest point of contraction, 140 m.m.

The fracture of the ingot weighing two tons is perfect in every respect.

The advantage of pouring such ingots with feeding heads is therefore very apparent. The *modus operandi* is as follows:

In order to keep the steel liquid in the feeding head, the latter is surrounded by brick walls and well banked up with sand, and is heated, so as to prevent the ingot from radiating its heat. Anti-Piping, during its reaction, develops an enormous

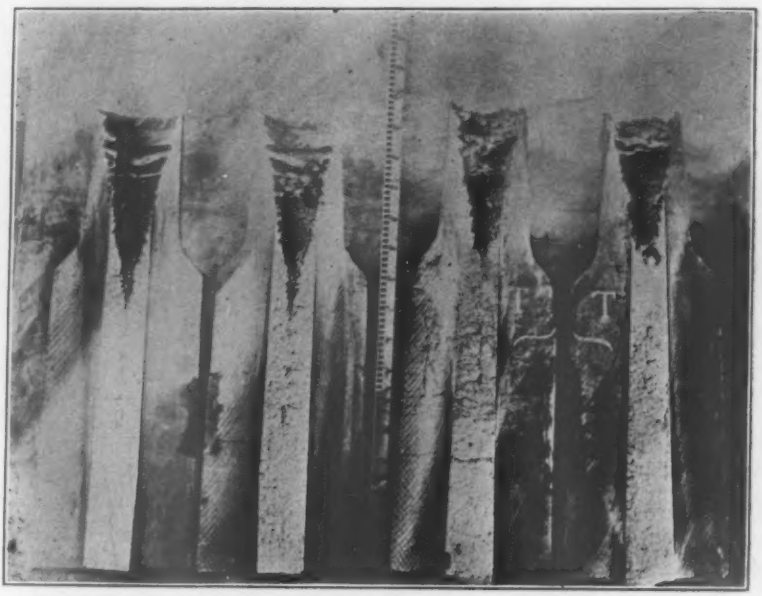

Fig. 2.

temperature, and in so doing, renders the contents of the feeding head, which was at the point of chilling, fluid again. It will then fill up the hollow spaces that have formed in the interior of the steel and the pouring of fresh fluid steel into the mold can continue until the piping is entirely removed.

The Anti-Piping Can is attached to an iron bar with a cross bar, to simplify the handling, and is then pushed into the mold. The can must be so fastened by either wire or wedge that it cannot slip up on the rod.

When the steel has been poured into the mold, the can is

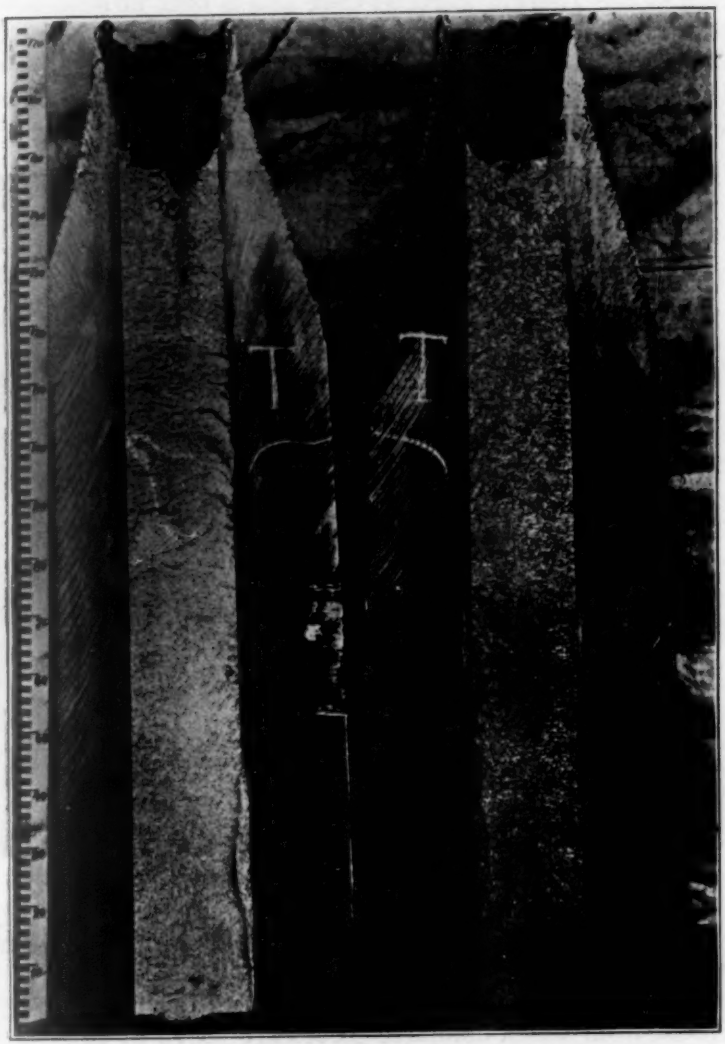

Fig 3.

pushed into the interior to a depth of about three inches or more, according to the size and weight of the ingot. The reaction of the Thermit starts at once and is over in from five to ten seconds. A violent ebulition of the steel takes place, and the slag separated by the Anti-Piping Thermit rises to the surface. This slag must be removed with an iron bar and more fluid steel must be then added out of the ladle.

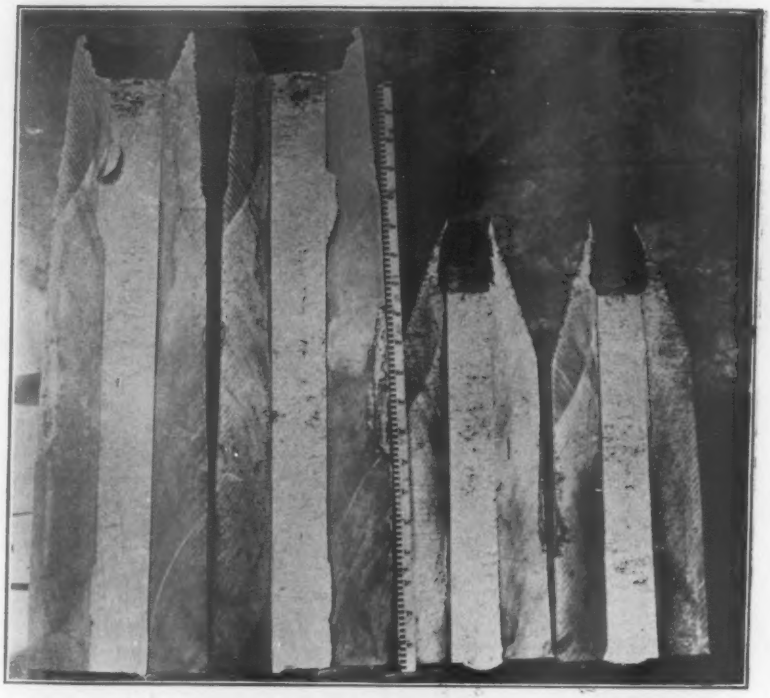

Fig. 4.

The Anti-Piping Thermit is supplied in various sized cans, according to the weight of the ingot.

Diosgyör Works used the Anti-Piping Thermit for such blocks from which complete pieces are rolled or forged, and have then ingots quite free from piping, or, in case of wrought iron blocks, only a small part has to be cut off.

The saving in material completely overbalances the cost of the application of the Anti-Piping Thermit and the actual cost

prices are not increased. Even should some of the blocks cast with feeding head but without Anti-Piping Thermit be not very much inferior to those cast with the Thermit, nevertheless the application of Thermit is considered a safer way than the other methods and the Diosgyör Works are convinced that the use of the Thermit is most advantageous. The clearest proof is the fact illustrated in Figures 1 and 2, where ingots poured with Thermit are of superior quality, even though no additional steel was poured in afterwards; in other words, the ingot showed a smaller extent of piping than those cast without Thermit.

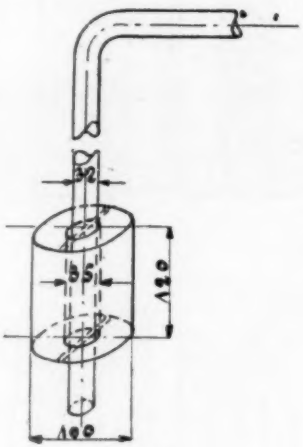

Fig. 5.

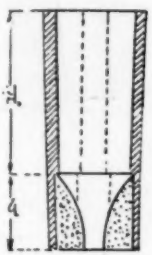

Fig. 6.

In the construction of the ingot mold, and particularly the feeding head, the essential point to be aimed at is to protect the liquid steel against loss of temperature. It should be kept liquid until the piping can be completely filled up from the feeding head.

A comparatively large mold must be provided for the feeding head, allowing for a sufficiency of material to fill up the piping. On the other hand, an unnecessarily large feeding head will simply mean waste steel and an unnecessary increase in the cost of manufacture, and is therefore to be avoided.

The mold represented in Figure 6, which was used for pouring the ingots shown in Figure 4, answers these conditions.

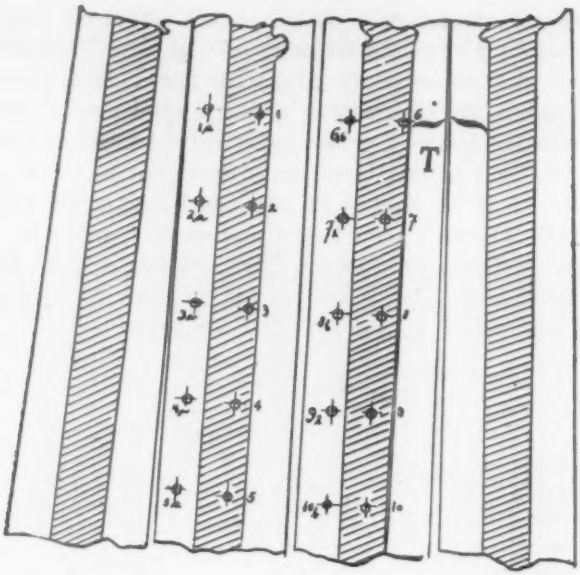

Fig. 7

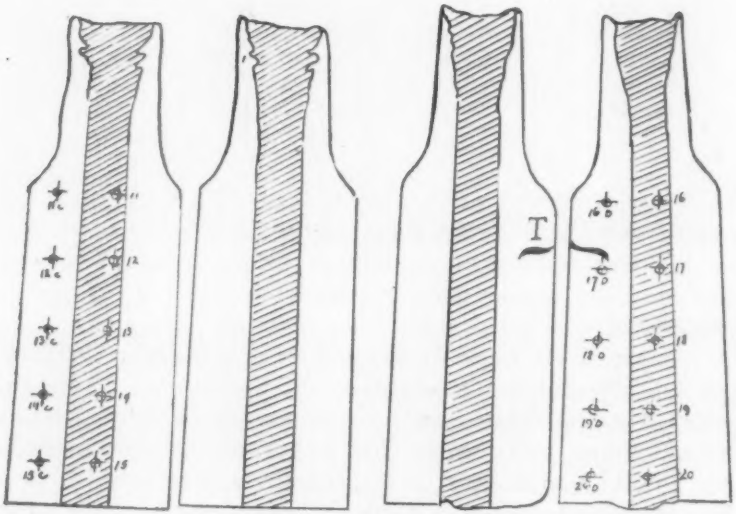

Fig. 8.

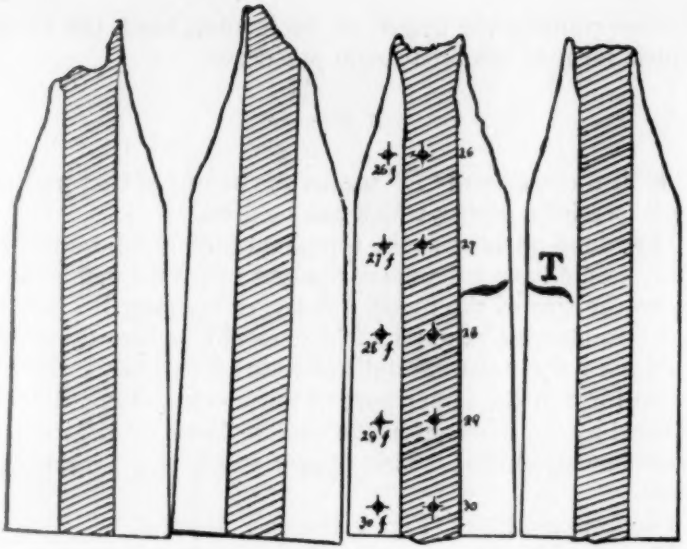

Fig. 9.

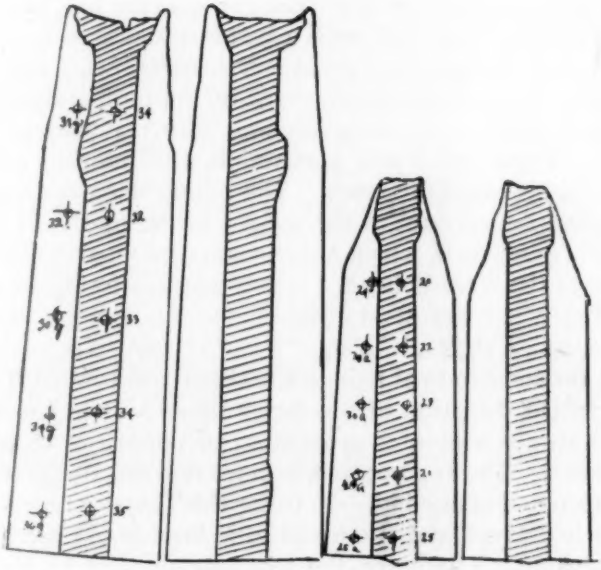

Fig. 10.

For ascertaining the height of the feeding head, the following empiric formula has been found practicable:

$$h = \frac{H}{2.4}$$

"h" is the head and "H" means the height of that part of the ingot free from piping which can be used.

The round opening at the top part of the mold, rammed with sand, should have a diameter of eight to twelve inches, according to the size of the ingot. A larger opening is inadvisable, as a considerable amount of heat would be lost by radiation. Even with the most careful handling of the head, the piping would form in the upper part of the block and could not then be filled by the material in the feeding head, on account of the latter having chilled. This danger is avoided by the narrow opening.

The four-ton block (Fig. 4) is a case in point.

The considerable amount of piping found in the square ingots of Figure 1, is due to the upper part of the ingot having been left open in its entire section and offering a large surface for radiation; besides this, the mistake had been made not to surround the mold with a bad conductor of heat. The liquid steel meeting with a good conductor of heat, such as the cold walls of the ingot mold, gives off its temperature to the latter too rapidly. It congeals and forms a coating in the mold, to which the liquid material in the interior gradually adds as congelation proceeds. The piping does not appear at the bottom, on account of the weight of the partly fluid material in the upper half, which latter cannot be filled owing to the absence of the feeding head. It is a matter of general observation that where the steel congeals slowly, some of the components, as "C," "Si," "Mn," "P," "S" and "Sb," segregate toward the longitudinal axis of the ingot and toward its upper part. In the direction of the longitudinal axis in the interior there is always a greater proportion of impurities than in the outer parts. The segregation is more marked the greater the time consumed in cooling. In using the Thermit reaction, this cooling is delayed and the material is kept liquid for a longer space of time. Therefore, the segregation must be greater in ingots treated with Anti-Piping Thermit than in those without.

ANALYSIS OF THE BORINGS TAKEN FROM THE BLOCKS.

DESIGNATION OF THE BORINGS.

RESULTS OF THE ANALYSIS IN %.

	Near the Longitudinal Axis.					*Near the Outside.*					
	1.	2.	3.	4.	5.	1a.	2a.	3a.	4a.	5a.	BLOCKS
C	0.231	0.172	0.173	0.174	0.172	0.164	0.194	0.204	0.194	0.201	CAST.
Si	0.191	0.172	0.168	0.168	0.168	0.186	0.186	0.186	0.186	0.186	Without
Mn	1.108	1.089	1.079	1.060	1.060	1.108	1.108	1.123	1.127	1.108	Thermit
Cu	0.127	0.127	0.111	0.119	0.111	0.111	0.111	0.096	0.111	0.111	
P	0.031	0.010	0.011	0.024	0.006	0.022	0.024	0.024	0.026	0.025	Fig. 1
S	0.055	0.070	0.080	0.050	0.040	0.070	0.050	0.055	0.055	0.040	
	6.	7.	8.	9.	10.	6b.	7b.	8b.	9b.	10b.	
C	0.231	0.163	0.172	0.182	0.154	0.172	0.184	0.184	0.183	0.192	
Si	0.191	0.172	0.191	0.196	0.191	0.186	0.186	0.196	0.168	0.168	With
Mn	1.089	1.038	1.038	1.060	1.026	1.089	1.127	1.108	1.127	1.108	Thermit
Cu	0.127	0.127	0.119	0.127	0.127	0.093	0.096	0.096	0.098	0.096	
P	0.026	0.020	0.013	0.024	0.008	0.019	0.025	0.019	0.024	0.023	Fig. 1
S	0.045	0.060	0.065	0.040	0.065	0.060	0.050	0.050	0.050	0.050	
	11.	12.	13.	14	15	11c.	12c.	13c.	14c.	15c.	
C	0.250	0.192	0.192	0.192	0.201	0.192	0.172	0.175	0.175	0.172	
Si	0.154	0.163	0.186	0.158	0.154	0.186	0.177	0.177	0.168	0.168	Without
Mn	1.098	1.079	1.108	1.050	1.108	1.169	1.108	1.159	1.127	1.108	Thermit
Cu	0.127	0.119	0.119	0.119	0.119	0.093	0.096	0.104	0.111	0.119	
P	0.030	0.024	0.019	0.009	0.008	0.028	0.022	0.023	0.021	0.019	Fig. 2
S	0.080	0.050	0.050	0.055	0.065	0.070	0.060	0.055	0.050	0.060	
	16.	17.	18.	19.	20.	16d.	17d.	18d.	19d.	20d.	
C	0.250	0.182	0.162	0.202	0.174	0.212	0.190	0.173	0.172	0.172	
Si	0.154	0.168	0.186	0.182	0.186	0.168	0.158	0.168	0.154	0.196	With
Mn	1.200	1.070	1.026	1.073	1.050	1.127	1.089	1.108	1.108	1.089	Thermit
Cu	0.111	0.104	0.119	0.088	0.096	0.111	0.104	0.104	0.096	0.085	
P	0.028	0.024	0.023	0.005	0.005	0.027	0.023	0.025	0.020	0.024	Fig. 2
S	0.100	0.080	0.050	0.030	0.025	0.060	0.080	0.060	0.075	0.070	
	26.	27.	28.	29.	30.	26f.	27f.	28f.	29f.	30f.	
C	0.409	0.290	0.251	0.231	0.251	0.283	0.223	0.242	0.223	0.223	
Si	0.187	0.159	0.181	0.163	0.177	0.150	0.191	0.177	0.177	0.177	With
Mn	1.171	1.118	1.036	1.026	1.060	1.159	1.169	1.169	1.159	1.127	Thermit
Cu	0.104	0.096	0.096	0.079	0.079	0.096	0.096	0.079	0.079	0.072	
P	0.029	0.019	0.016	0.016	0.018	0.019	0.023	0.018	0.020	0.014	Fig. 3
S	0.050	0.035	0.040	0.030	0.030	0.025	0.030	0.040	0.040	0.015	
	31.	32.	33.	34.	35.	31g.	32g.	33g.	34g.	35g.	
C	0.329	0.241	0.192	0.192	0.211	0.344	0.234	0.223	0.184	0.194	
Si	0.144	0.140	0.140	0.150	0.140	0.177	0.150	0.177	0.168	0.168	Without
Mn	0.983	0.887	0.858	0.887	0.922	0.956	0.956	0.925	0.915	0.915	Thermit
Cu	0.079	0.072	0.072	0.072	0.072	0.072	0.067	0.072	0.072	0.072	
P	0.020	0.019	0.014	0.014	0.015	0.015	0.006	0.019	0.006	0.014	Fig. 4
S	0.030	0.025	0.030	0.020	0.030	0.015	0.015	0.020	0.015	0.015	
	21.	22.	23.	24.	25.	21c.	22c.	23c.	24c.	25c.	
C	0.525	0.481	0.524	0.484	0.484	0.438	0.492	0.492	0.472	0.458	
Si	0.196	0.191	0.214	0.205	0.210	0.196	0.205	0.186	0.196	0.196	With
Mn	1.089	1.073	1.050	1.054	1.025	1.089	1.089	1.089	1.089	1.089	Thermit
Cu	0.096	0.096	0.096	0.085	0.079	0.079	0.079	0.088	0.080	0.085	
P	0.033	0.018	0.031	0.027	0.027	0.023	0.025	0.030	0.025	0.027	Fig. 4
S	0.020	0.015	0.035	0.015	0.020	0.020	0.015	0.020	0.015	0.015	

In order to obtain confirmation of this, holes were drilled into the fracture of the ingots, in the direction of the longitudinal axis, as well as in the outer parts, taking the borings for the purpose of analysis. The accompanying table will show the results obtained. The thousandths parts have been left out. Following are the observations made in connection with these analyses:

First—On using a mold without feeding head, the steel congeals comparatively quickly and the effect produced by Anti-Piping Thermit cannot be so great as in those cast with a feeding head. There is, therefore, no great difference in the segregation.

Second—In ingots provided with feeding heads, in which the steel in the interior of the upper half of the ingot remains liquid for a comparatively longer space of time, the segregation of various elements and their situation in the respective parts of the ingot, due to specific weight, is more distinct. Naturally, in ingots cast with Thermit, the segregation reaches a greater extent.

In Figure 8 (analysis 11-20), cast with Thermit, a considerable increase in the contents of "C," "Mn," and "S" is observed in the upper part.

In the analysis obtained from Figures 9 and 10 (analysis 21-31), the rapid increase of "C" is striking. This may be explained by the fact that the ingots were cast without Thermit and the head covered with charcoal, from which the liquid steel absorbed a quantity of carbon, which in its turn was carried into the interior of the ingot by the material running from the feeding head into the piping.

THE FRANK THOMSON RAILROAD SCHOLARSHIPS.

At a meeting of the Board of Directors of the Pennsylvania Railroad Company, March 27, the offer of Anne Thomson, Frank Graham Thomson and Clark Thomson of a fund of $120,000 to establish what are to be known as the "Frank Thomson scholarships" was accepted and approved. The purpose is to afford to "sons of living or deceased employees of all the lines of the railroad an opportunity for a technical education, so as to better enable them to qualify themselves for employment by the company." Competitive examinations are to be held, open only to sons of Pennsylvania employees, "corresponding in general to the entrance requirements of the scientific departments of the higher class universities, colleges and technical schools." After passing the examinations held by the company the winner of a scholarship must qualify for admission to one of the technical schools or departments approved by the company before he receives his certificate entitling him to draw upon the scholarship fund. Beginning this year two scholarships, each of which amounts to $600 a year, are to be filled, and every year two will be added. After four years two will be graduated annually, keeping a total of eight men in college all the time.

HOW SCIENCE IS HANDICAPPED.

A paragraph of undoubted economic interest is the following, which was written by Mr. S. F. Emmons in summarizing for the forthcoming "Economic Bulletin," the work of the United States Geological Survey, during 1906, in the investigation of metalliferous ores:

"The increasing exodus of members of the economic force of the Survey in consequence of their employment by large mining organizations at salaries much greater than those they have been receiving from the Government, seriously impairs the efficiency of the work of this branch of the Survey. It is only by years of practical experience in the field that the geologist, however excellent his preliminary training, becomes competent to carry on independent work in investigating a mining district, and the loss of trained men in this work is, for a time, irreparable."

RIFLING STEEL PIPE for reducing friction in oil lines was described in a paper read before the Engineers' Society of Western Pennsylvania by F. N. Speller of the National Tube Company, who referred to the fact that in the California field a quantity of steel pipe has been rifled, the object being to cause the viscous oil intermixed with a small percentage of water to whirl as it moves rapidly through the pipe. Thus, when a sufficient velocity is attained, a layer of water flows between the oil and the pipe, reducing the friction in the line. It has been found quite practicable to roll spiral corrugations $\frac{3}{32}$ in. deep in the surface of the pipe by means of six wheels set equidistant around the circumference and slightly inclined to the axis of the pipe, so as to make a complete revolution on the surface of the pipe every ten feet. The material seems to stand this treatment cold without difficulty.—*Metal Worker, Plumber and Steam Fitter.*

(Stated Meeting held Thursday, January 26th, 1906.)

The Schuyler Mine.

By J. H. Granbery,

Associate Member Am. So. C. E., Member of the Institute.

Vast sums are invested in the mining and reduction of copper ore in the United States, but only recently has this industry been brought to its present stage of development; it seems, therefore, that a more than passing interest may attach to the early history of what was at one time not only the only copper mine, but, indeed, the first mine of any kind operated by Europeans within the limits of the original thirteen States. Much of the mechanical development of the present day is to be traced directly to the far-sighted men who brought to, and installed in, this country the first steam-driven machinery; the first mine and the first steam engine are indissolubly associated with the engineering, as they were formerly with the political, development of our country.

The Schuyler Mine (which this account considers) is located upon property, secured by Captain William Sanford of the British Army, under the terms of an agreement made with William Kingsland. The present town of Kingsland, New Jersey, was named from the old proprietors, and situated upon a part of the estate. Kingsland is said to have been a kinsman of Oliver Cromwell. The patent of Captain Sanford was issued July 4, 1668, "in lieu of the payment of twenty pounds Sterling per annum, forever," as well as on the payment to natives of several hundred strings of wampum, knives, brandy, etc.; this patent conveyed approximately 10,000 acres of meadowland and 20,000 acres of upland, lying between the Hackensack and Passaic rivers, and from their intersection to a point seven miles above; it was known in those days as the "New Barbadoes." Shortly after its acquirement by Sanford,

he transferred to Kingsland the upper portion of this tract. In the year 1710, Arent Schuyler purchased from Kingsland a large tract of land comprising the lower portion of Kingsland's property; upon this tract the mine was located and the Schuyler's home was erected (but afterwards destroyed by fire); and along the eastern bank of the Passaic, opposite the present town of Belleville, stands to-day another old frame mansion, pointed out as the home of the Schuylers', more than a century ago.

Arent Schuyler was born at Albany, N. Y., in 1662, and was the sixth son of Philip Pieterse (Van?) Schuyler (who came from Holland a few years before and was one of the two founders of the family in America.)

In the eastern portion of the upland, at what is even now known as Schuyler's Corner, stood the house of Arent Schuyler; on the meadow land below the hillside, between it and the dense cedar swamp, lay the fertile soil that he cultivated as a part of his plantation. Here, in 1714 or 1715, a discovery was made by a negro slave who, while ploughing, turned up a large stone, the weight of which so excited his curiosity that he carried it to his master. Upon Schuyler's learning that it came from a bed of rock of the same character, he sent it to England for analysis; he learned that it contained nearly eighty per cent. of copper.

The old tradition runs to the effect that Schuyler, wishing to reward the virtual discoverer of the mine, gave him his freedom, and told him to make three wishes, which would be granted in addition. The first wish was to live with his master as long as he lived, and to have a dressing gown "with big brass buttons, just like massa's." The second wish was for all the tobacco he could use; the negro was at a loss to name the third. He was urged to ask for something valuable; after studying for some time and scratching his head, he said, "I guess, massa, I'll hab a little more 'baccy."

The scanty literature of those days makes mention of the mine; it was evidently of considerable importance, for Brig. Gen. Robert Hunter (Governor of the Colonies of New York and New Jersey), writing from New York, November 12, 1715, to the Lords of Trade, states regarding it: "There being a Copper Mine here brought to perfection, as you may find by

the Custom House books at Bristol, where there was imported from this place about a Tonn in the month of July or August last, of which copper farthings may be coined," etc.[1]

Also, the records tell us that "in April 1721, there were 110 casks of ore from this mine shipped from New York to Holland, and the Surveyor of the Port of N. Y., wrote that 'Copper Oare now rises very rich and in great plenty in a new-discovered mine of one Mr. Schuyler in New Jersey.' "[2] The shipment of the ore to Holland excited the apprehensions of the Lords of Trade, who suggested that it should be prevented by act of Parliament. At the request of the Duke of Newcastle, one of the Lord Justices of the Treasury, Governor Montgomerie conferred with Col. Schuyler, in relation to the matter, but could only secure from him the promise that the English Copper Co. should have the first sight of his ore when his ships arrived in England with it.[3] This was in 1730. Curiously enough, the New Jersey Legislature came to the relief of the English manufacturers, in 1734, by imposing a duty of 40 shillings per ton on all copper exported from the province not directly to Great Britain; and still more strangely, the first complaint against this measure came from Bristol, England, where were extensive brass and copper factories. It was found in practice that the law was evaded by shipping the ore to New York and thence to England or other countries; but the Bristol traders feared the act would discourage mining operations in the province.[4]

For many years the mine yielded large quantities of rich ore, until it was worked as deep as hand and horse power could clear it of water; of this period we learn much from the following extract from a book of that time:

"Schuyler's Copper Ore is from a Mine in Jersies, but exported from *New York*, therefore it is mentioned in this Section. In the beginning of this Discovery it seemed to be very rich; it appears that it was formerly wrought by the *Dutch*, because in new working of it, were found Hammers, Wedges, &c. it sold in Bristol the Ore at £40 ster. per Tun. The Cartage to *Hudson's* River is short, and their first Agreement with

[1]Thos. F. Gordon Gazetteer of N. J., Trenton, 1834.
[2]New Jersey Archives V, p. 7.
[3]New Jersey Archives V, pp. 7, 9, 267.
[4]New Jersey Archives V, pp. 376-406.

the Miner, was to allow him one-third of the Ore for raising and laying it above Ground; it was done up in quarter Barrels, whereof six made a Tun. The richness of this Copper Mine made so much Noise in the World, that a few Years since, to engross this Ore for the benefit of *Great Britain*, it was by Act of Parliament enumerated; but lately it has not been Wrought and Exported, as appears by the quarterly Accounts of the Custom-House of *New York*; I cannot account for this."[5]

In the meantime Arent Schuyler had died; his will was proven July 6, 1732, the mine being left to his three sons. Col. John Schuyler, one of his sons by his second wife, had the management of the mine for himself and his brothers.

"Benjamin Franklin visited the mine in 1749, and on February 13, 1750 N. S. (New Style) he writes to Jared Eliot from Philadelphia:[6] 'I know of but one valuable copper mine in the country, which is that of Schuyler's in the Jerseys. This yields good copper and has turned out vast wealth to the owners. I was at it last fall, but they were not then at work. The water has grown too hard for them, and they waited for a fire-engine from England to drain their pits; I suppose they will have that at work next; it costs them one thousand pounds sterling.'"

That Dr. Douglass could not account for the non-working of the mine is not strange when we consider the difficulty of communication; indeed, the engine, ordered in 1748 or 1749, was not shipped from England until four years had passed.

Steam engines (or more truly speaking, atmospheric engines, for all of that date were of the Newcomen type) were then being used with great success in the coal mines of that part of England known as the "Black Country," and in the deep tin and copper mines of Cornwall.

Joseph Hornblower and his sons were engaged in the construction of "fire engines," as they were called at that time, and it was to him that Col. John Schuyler sent for the machine which was to play so important a part in the development of

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[5]"A Summary, Historical and Political, Of the first Planting, progressive Improvements, and present State of the *British* Settlements in NORTH AMERICA. By William Douglass, M. D., Vol. 2. Boston, New England; Printed and Sold by D. Fowle in *Ann Street* facing the Town Dock. 1753." pages 257, 258.

[6]Works of Franklin, edited by Jared Sparks, Boston, 1838, V 1, p. 107.

mechanics in this country. Col. Schuyler also asked that an experienced engineer should accompany it and set it in position. Josiah Hornblower, then only twenty-four years of age (for he was born in Staffordshire, England, on February 23, 1729), built this engine in England and left home May 8th, 1753, embarking on the sailing ship *Irene*. The engine arrived at New York, September 9, 1753; it was landed at Second River (now Belleville, N. J.), and was carted thence to the Schuyler mine, where Hornblower set it up. In account books of the Schuyler mine, we find this item:

> "1753
> Sept. 25—To cash pd for 8 days, carting ye engine
> & boards to ye mine at 6 s - £2, - 8 ."

The shaft to which the engine was taken was that now known as the Victoria; the engine house was built about 300 feet northwest of the shaft, and the machinery was installed by Hornblower. It was sufficient to keep the flow of water down for many years.

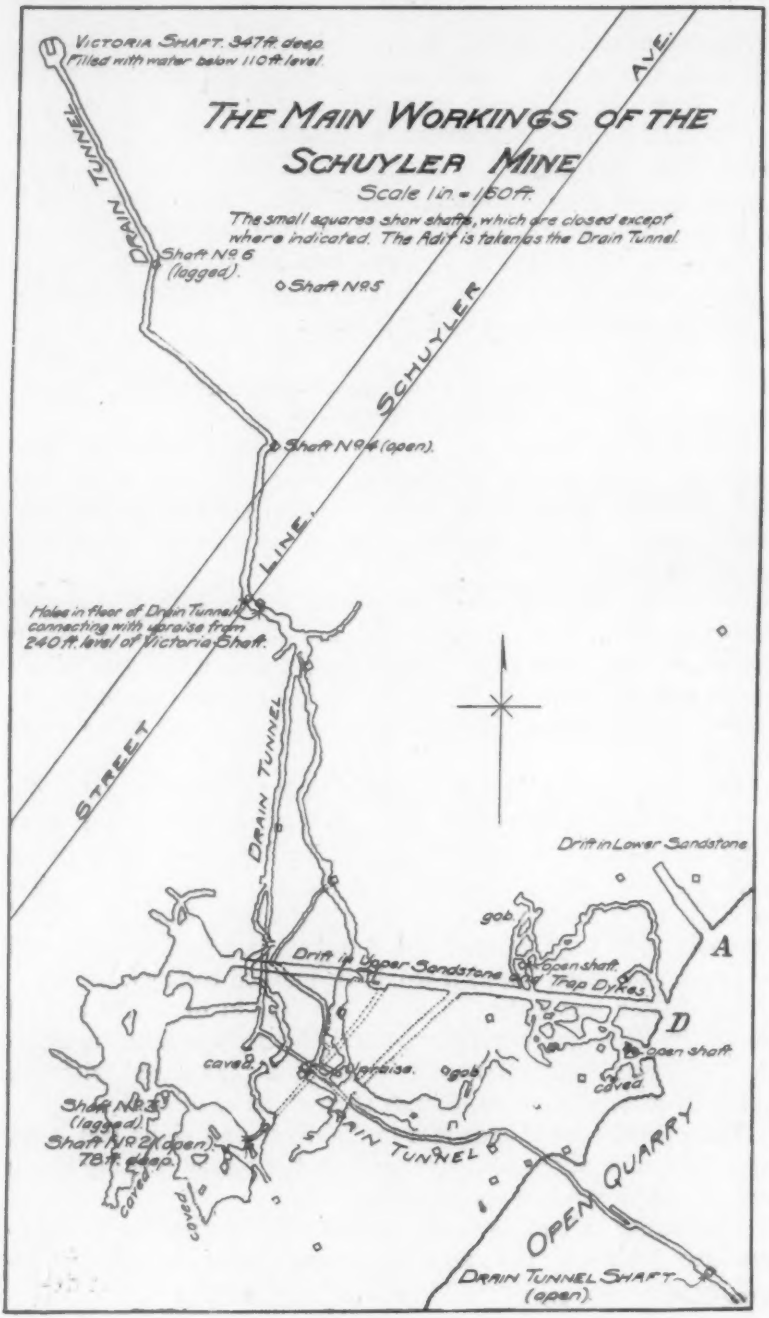
When first brought over there were no facilities for engineering work in the colonies; and the pipe, as well as large numbers of duplicate pieces, was brought with it. Some of the old pipe has been raised; it illustrates the radical difference between the practice of the older day and that of our more modern times.

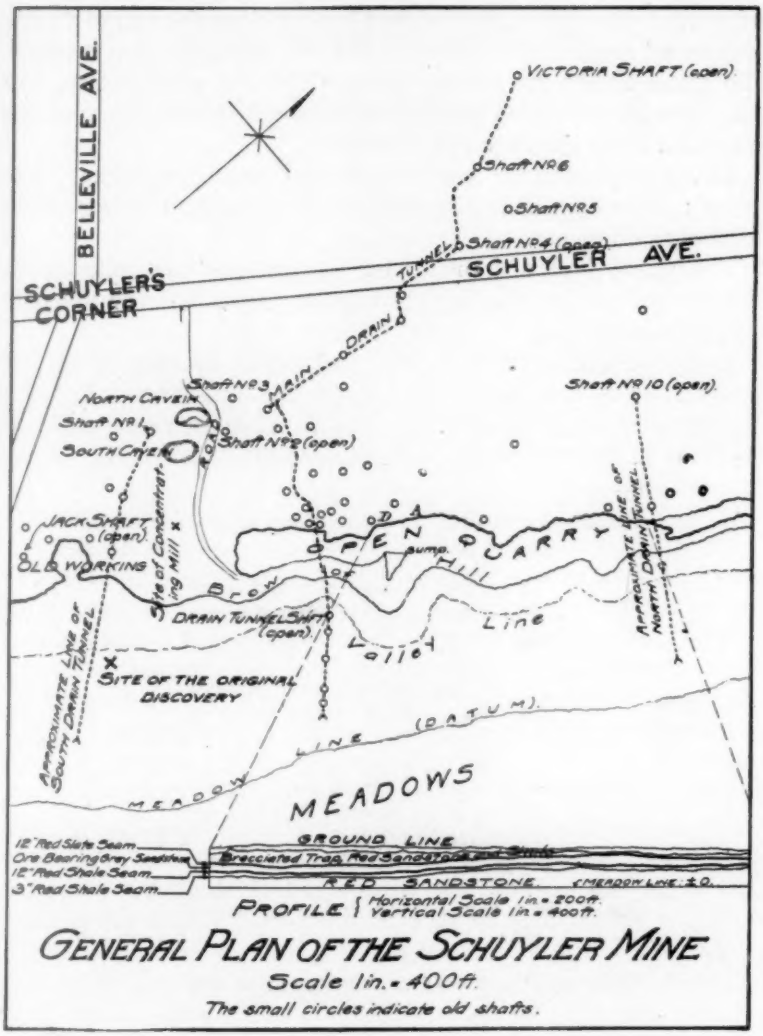
The pipe was of cast-iron, made in lengths of about eight feet; each individual length had a pair of trunnions cast upon it by which means it was kept in a vertical position while being lowered into place. Some of the pieces of the original pipe brought from England bear the weight mark; thus: "1 2 40," meaning, not 1240 lb., but one ton, two hundred weight, and forty pounds (2504 lb., as it would be marked to-day).

The boiler was either eight or ten feet in diameter and of about the same height; it was placed directly beneath the cylinder, and was connected to it by a short pipe fitted with the valve by which the admission of steam was regulated.

The cylinder was three feet in diameter and eight feet long, and the stroke about six or seven feet, the piston making about ten or twelve strokes per minute.

The safety valve was simply a heavy lid, resting on an opening into the boiler; the valve movement was of the simplest de-


THE MAIN WORKINGS OF THE SCHUYLER MINE
Scale 1 in. = 150 ft.
The small squares show shafts, which are closed except where indicated. The Adit is taken as the Drain Tunnel.
Victoria Shaft. 347 ft. deep. Filled with water below 110 ft. level.
Drain Tunnel
Shaft No 6 (logged).
Shaft No 5
Shaft No 4 (open).
Schuyler Line.
Ave.
Street
Holes in floor of Drain Tunnel connecting with upraise from 240 ft. level of Victoria Shaft.
Drain Tunnel
Drift in Lower Sandstone
gob
A
Drift in Upper Sandstone
open shaft.
Trap Dykes
D
open shaft
caved
caved
Upraise.
gob
Shaft No 3 (logged).
Shaft No 2 (open) 78 ft. deep.
caved
caved
Drain Tunnel
Open Quarry
Drain Tunnel Shaft (open).



GENERAL PLAN OF THE SCHUYLER MINE

Scale 1 in. = 400 ft.

The small circles indicate old shafts.

scription—a narrow board connected to the walking beam, and holding pins for adjusting the point of cut-off.

Small tanks, holding water for condensing the steam, were supported on a frame several feet higher than the cylinder; the condensed steam drained into a hotwell alongside the furnace. The space above the piston was open to the atmosphere, and the pressure on it was just a little more than necessary to lift the water from the required depth.

The pump cylinder was ten inches inside diameter; the pump rod was six inches square, the original pipe being about six inches diameter.

The pump had a capacity of 134 gallons per minute, or 180,000 gallons per day, (eight hogsheads per hour as given in the old records).

Many of the account books and other records were destroyed by a fire which destroyed the residence of Arent H. Schuyler, on November 15, 1870. Enough remains, however, for us to abstract the following items:

"1753.

Oct. 25—To carting 624 bushels lime to ye mine for ye engine house, £ 2 - 0 - 0

To carting 66 days, clay and stone & 300 boards to ye mine 6 s. per day, £19 - 16 - 0

To 11 days carting 3000 shingles and ten thousand bricks &c to ye mine, £ 3 - 6 - 0

"Dec. 28—To cash pd for 16 days carting timber to ye sawmill & mines for ye engine house at 6 s. £ 4 - 16 - 0

"1754

Jan. 8—To 6 days slaying timber for ye engine, £ 1 - 16 - 0

"Feb. 24—To 10 days slaying stone and timber for ye engine, £ 3 - 0 - 0

"Mch. 1—To cash pd for carting timber for ye engine house, 15 - 0

"Apr. 2—To cash pd for sashes in the engine house, 10 · 6

"June 13—To cash paid Josiah Ward for 1 days carting fire stone for ye engine from the mountain, 8 - 0

132 days carting stone & timber for the engine house at 6 s. per day £39 - 12 - 0

"July 15—To pd Elizabeth Davis for a tree for ye engine house, 10 - 0

2 days carting, 12 - 0

"Oct. 10—To pd Thos. Childs for 1 1/2 days mason work at the engine house 9 - 0

"Oct. 28—To pd Thos Plummer & Thos. Barnes for putting the boiler at ye engine house together, £35 - 1 - 6

"1755
Jan. 11—To pd Benj. Smith for work done on ye engine house, as per his acct. & receipt, £52 - 5 - 6

"Mar. 12—To 52 days carting stone & fire wood for ye engine, £15 - 15 - 0"

The engine was, therefore, probably started some time in March, 1755. The shaft was 100 feet deep at that time, and was carried deeper as the work of mining progressed, until, owing to the increasing flow of water, the engine was no longer able to keep the mine dry. This shaft was then abandoned and other shafts were worked to some extent; but, within a few years, operation was entirely abandoned.

Up to the time when this shaft was sunk (about 1735), the mining had been done by drifts into the side hill; some of the other shafts upon the property were undoubtedly sunk between this time and the arrival of the engine.

In 1761, Hornblower and John Stearndall leased the mine from Schuylers—agreeing to pay one-seventh of the ore as rent—for fourteen years, the lease being afterward extended ten years longer.

On March 25, 1765, Stearndall & Hornblower assigned one-half their interest to Philadelphia parties; John Kidd, William Parr, Judah Fulke, and William Dowell. These worked it until 1768. During 1768 and 1769, it lay idle, but it was

started again by New York operators and kept up till 1773, when the engine house was destroyed by fire.

After this, no work was done for twenty years, except surface digging. For the years named herewith, the account books of Hornblower show that the receipts from the mine were: 1765, £670, 7s. 9., New York money; or in dollars, $1,676; for 1766, $4,357.87; for 1770, $4,785; for 1771, $7,787; for 1772, $1,237; for 1773, $2,855. Ore brought from $8 to $10 per 100 pounds.

In 1770, only forty-one tons of copper ore were exported from America, being valued at £853, 13 shillings sterling, or less than £21 per ton.

An officer of the Continental Army in a Massachusetts regiment, stationed in New York in 1776, in a journal kept by himself and Isaac Bangs, gives an account of visiting the celebrated copper mine. He, with two other officers and eighty men, was detailed to go into New Jersey and cut timbers with which to obstruct the harbor against the enemy's vessels. They were provided by Schuyler with a guide, with whom they visited the celebrated copper mines, the engine house being then in ruins, having been burned by a discharged workman four years before..

Work was begun a short distance west of Hackensack river, in a cedar swamp belonging to Arent Schuyler; this swamp is now obliterated, the only traces of its location consisting of old stumps and tree trunks submerged beneath the level of the meadows on either side of the Jersey City and Belleville Turnpike.

The road leading to Schuyler's homestead was built by Hornblower in 1765, and was used at this period by the Colonial troops as a military road. It formed the principal means of communication between New York harbor and inland New Jersey. The cedar swamp was so dense that Hornblower was obliged to do most of the survey work by the aid of lanterns.

The Schuylers, as well as the Hornblowers, were ardent patriots; and Hornblower did not return to England, as was his first intention, but remained in this country and married Miss Kingsland, whose father's plantation adjoined that of the Schuyler's. It may here be remarked that the late highly honored and esteemed Chief Justice Joseph C. Hornblower,

who was born in Belleville, and died in Newark, full of years and distinction, in 1864, was the youngest of a family of twelve resulting from this union.

This was really the first mine of any value that had been discovered after nearly a century of prospecting.

When first worked the yield averaged about 100 tons per annum, and the mine was highly profitable. *Gordon's Gazetteer* says: "From the books of the discoverer, it appears that before the year 1731 he had shipped 1386 tons to the Bristol Copper and Brass Works."

England did not permit the smelting and refining of ore in the Colonies, and there were no facilities for doing machine work, so that the mine lay idle during the Revolution. On February 4, 1793, however, the New Jersey Copper Mining Association (headed by Jacob Mark, Philip A. Schuyler, and Nicholas I. Roosevelt) leased the mine from Arent J. Schuyler (son of Col. John Schuyler, now deceased) for a term of twenty-one years, with the privilege of renewing it for twenty-one more. The rental was fixed at one-tenth of the ore for the first term, and one-seventh for the second; the lessees being required "to erect and rebuild a sufficient steam engine within eighteen months and to keep at least eight men at work for not less than eight months in the year."

On February 5th, 1753, they agreed "for the better carrying into execution their intentions of extending the Copper Works by Erecting Furnaces & Battering & Rolling Mills, Do declare that the works shall be carried on under the name and firm of the New Jersey Copper Mine Association, property represented by 640 shares divided among those interested, 3 directors to be elected annually. The first Election for chusing directors shall be on the first Monday in January after the first steam Engine is Erected, untill which time the whole management of the Company's concerns shall remain with the Lessees." The Directors were authorized to reserve not more than $8,000 annually until $20,000 should be accumulated which was to be invested as capital, and used as necessity might require for the betterment of the company.

Mr. Hornblower was employed to take charge at a salary of $60 per month, with the promise of a one-sixteenth interest in the concern.

Roosevelt, Mark and Schuyler, Directors of the New Jersey Copper Mine Association, bought from Hornblower, August 29, 1794, six acres of land on the brook known as Second river, with the privilege of erecting a dam and coal house. Here they established a foundry and machine shop; and here Josiah Hornblower built for them a stamp mill, the first one in this country, as the shaft where the original engine was set up was also the first to attain any considerable depth or produce ore of commercial value. Both the mill and shop were operated by water power, and to this mill the product of the mine was taken for stamping and concentrating. The walls of the old mill are still standing, and a portion of the water wheel (which was used for driving), as well as the dam, which was built by Hornblower for the needed supply of water power.

Roosevelt named these shops "Soho," after the large establishment in the old country; and it was in this machine-shop that the first steam engine built in this country was made.

The smelting works were in charge of one Smallwood; and John Hewitt[7] and a German named Rhode, were employed here, the former to make patterns and Rhode to make castings for the engine for Chancellor Robert R. Livingston's steamboat, the *Polacca*. This boat started on her trial trip on October 21, 1798, was sixty feet long, and was propelled by a jet of water forced out of the stern by a powerful centrifugal pump. The engine had a cylinder twenty inches in diameter and of two feet stroke.

The management under the new arrangement was not satisfactory to Mr. Hornblower, and in 1794 he retired. The company introduced German miners because of the low wages, but the work was abandoned early in the 19th century; the old engine was broken up and the material disposed of. The boiler, a large copper cylinder with a flat bottom and dome-shaped top, was carried to Philadelphia. This relic (regarding which an article is given in "Atkinson's History of New Jersey," dated 1878, and from which a portion of this account is taken) is a piece of the cylinder about six feet long and four feet in diameter. It finally passed into the hands of David M. Meeker & Son, the malleable and gray-iron founders, and was by them

[7]An ancestor of ex-Mayor Abram S. Hewitt of New York City.

exhibited at the Centennial Exhibition. In a chapter devoted to "Mines, Minerals, Stones and Fossils" of an early history of the United States, occurs the following: "A copper mine, on the Pasaic, a few miles north of Newark in New Jersey, has been wrought to advantage, and an association by the name of the Soho company, has been incorporated for the purpose of prosecuting the business."[8]

An effort to work the mine in 1833 (when an English company took hold) is referred to by I. Finch,[9] as follows:

"The mines are now reopened, a steam engine erected to drain them, and the works are proceeding with spirit. It is the only copper mine worked in the United States."

The mine was at this time under the supervision of William Tregaskis, and the "Victoria" shaft was reopened to a greater depth and a more powerful engine installed. It is supposed that Tregaskis gave the shaft its name, for in later operations it is always so referred to. It is not known how long this company operated, but it is supposed it found the ore of less value than represented.[10]

The mine was worked in 1855-1856 by a Philadelphia company, for which Mr. Theodore Moss was engineer; but the work done between 1833 and 1859 was but little. Some parts of the mine were worked by a man named Cathuey, but on a contract basis, and for unknown parties.

In 1859, the Brisk company acquired the mining rights and property, but it sunk no shafts. All the shafts upon the property were sunk at some time previous to this. The company, however, opened some of the old shafts and in one of these were discovered an old horse pistol, a silver tea set, and a num-

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[8] "Elements of Useful Knowledge. By Noah Webster, Jun. Esq. Increase Cook & Co., New Haven, 1808." Vol. II p. 86.

[9] "Travels Through the United States and Canada." London, 1833, p. 277.

[10] "In 1833, when a new company was forming to work the mine, it was represented that 'the ore of the principal vein yields from 60 to 70 per cent. of copper, and the vein will produce, it is supposed, from 100 to 120 tons of ore annually, which yields from 4 to 7 oz. of silver to the hundred pounds; and, like most copper ores, a small portion of gold. When pure copper was sold in England at £75 sterling the ton, the ore of this mine was shipped from New York for that market at £70 the ton.' (£70 N. Y. Currency—$175)." (*Gordon's Gazetteer*, p. 12.)

ber of silver spoons, bearing upon them the names of some of the old families throughout this section. The find was probably a portion of some robber's plunder left there for safe keeping, and for some reason never removed. Brown, mine captain for the Brisk company, operated the mine from 1859 to 1865 with much of the old machinery. At this time it was known as the "Victoria Copper Mine," and there were about 200 men employed as miners, laborers, and workers in the mills. In 1865, presumably in February, an accident happened to the pump; before repairs could be made the water rose so high that the proprietors stopped work, thinking that improved processes would enable the treatment of the ore in this country instead of sending it to Swansea, Wales, where all the ore was formerly sent. The mine was abandoned and many tools were left in the lower drifts, as the water began to rise before the miners had an opportunity to collect them.

The Victoria shaft is reported to be 347 feet deep, but all is mud below the 240 foot level and difficult of access. The old Cornish pump is still in position at the bottom of the shaft, buried in mud and fallen timbers. It is said that there are three drifts from the bottom of the shaft, one toward the northwest about 180 feet long, one running southwest 180 feet long, and the third running north about 210 feet. The mill at this time was near the mine and had twenty-five stamps of the old Cornish type with wooden stems. The ore as it came from the mine was cobbed and hand-picked. The high-grade material was shipped without further treatment, and the lower-grade was concentrated by means of jigs and buddles. When the Brisk company ceased operations, their engine house caught fire during the night and burned down. The machinery, antiquated even for that time, was inefficient, and the company quietly passed out of existence. They worked, however, too near the surface in one portion of the mine, and in 1866 a cave-in occurred, now known as the South cave-in, engulfing a barn which was built over it on the surface.

In 1892, a company, known as the New York and New Jersey Mining Company, endeavored to work the mine, but its capital was not sufficient. It robbed the pillars where some of the best ore had been left, brought the surface down in another cave-in, and ceased operations.

In the fall of 1899 an option was secured upon the property, and the three interested parties made examinations and cleaned out two of the old shafts. They afterward promoted a company, known as the Arlington Copper Company, and capitalized at $2,500,000, to operate the mines. With this company the author was, for a time, connected, as engineer in charge of construction, but resigned before the end of a year.

The material "has not proved as susceptible to the proposed chemical treatment as was expected." The money "was expended under the direction of an 'expert' in the installation of a plant of unique design, with good machinery, but no local metallurgical value. When run on the ore it was found that the tanks would not hold the solution and the copper would not precipitate."[11] Part of the older portion of the mine is at this writing being worked as a stone quarry; the sandstone has a commercial value as a building material.

The geological formation is Triassic, gray and red sandstone and shale, with intrusive trap dikes. The sandstones are inclined at an angle of about 9° to the horizontal; the trap is partly brecciated and often forms, with the sandstone, a metamorphic conglomerate. The ore is the cuprous sulphide, chalcocite (Cu_2S) and the carbonates malachite and azurite. (Azurite is rare.)

The first mentioned carries about 78 per cent. and the two latter about 57 and 55 per cent. of copper respectively, when pure. Therefore, the original discovery on the outcrop must have been a piece of chalcocite. Small quantities of cuprite or red oxide, and of copper silicate are also found; as well as minute (and scarce) particles of native copper. "The ore itself is not in any vein with well marked boundaries, but occurs in pockets, or bunches, and seams which ramify through two thick layers of sandstone and a thin bed of shale. There are numerous faults in the deposit, and it is at these points and in connection with small trap dikes that some of the richest ore is found. There is a considerable shaly slate which assays from six to seven per cent." The ore also occurs "as finely scattered particles,[12] or as thinly diffused coloring matter."[13]

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[11]Annual Report of the State Geologist, Trenton, N. J., 1902.
[12]In the shale and sandstone. [13]In the sandstone. (J. H. G.)

Forty-two shafts in all have been sunk at various times and places, many of them connecting with passages of the most tortuous character; eight of them connect with the three drain tunnels which have been run for unwatering the mine. The longest of these tunnels is 1300 feet in length, and connects through a drift with three large chambers that have been stoped out. One of these measures 670 feet in perimeter.

The mine has been the producer of other things than copper. Nearly a score of years ago it was the scene of a novel depicting the woes of one "Maggie Tilby," who is actually reputed to have made the abandoned workings her dwelling place and to have earned the title of "witch" in consequence. It is also reported to have served, during the Revolution, as a hiding place for the spies in the Colonial Army; even now it has, what lonely and abandoned spots seem always to obtain in time, a "haunt."

The ghost stories are, seemingly, not confined to the rosy descriptions of the promoter. Since early in the 19th century, most of the working appears to have been of the public rather than of the mines; and for the past three years, the entire establishment has been idle, a prey of the speculator and the cause of much disappointment and legal quibbling. It may be that the days of its usefulness as a producer of copper are over. Certain it is that where a hundred and fifty years ago teamsters were carting "fire stone" to the historic engine, a settlement of the distinctly modern suburban type is fast obliterating the last traces of the old land marks.

In a paper covering a subject of such historic interest, the author must, of necessity, become more or less a compiler. Acknowledgments are due for much of the information contained in the foregoing, to various reports of the State Geologist of New Jersey, to a paper on "Josiah Hornblower," read by William Nelson before the New Jersey Historical Society at Newark, May 17, 1883, and to Mrs. Cortlandt Van Renssallaer.

(*To be continued.*)

THE FRANKLIN INSTITUTE.

(*Annual Meeting, held Wednesday, January 16, 1907.*)

Work of the United States Reclamation Service.

F. H. NEWELL, Chief Engineer of the Reclamation Service.

The work of the Reclamation Service is the outcome of what is known as the Reclamation Act, signed by the President June 17, 1902. This Act sets aside the proceeds of the sale of public lands in thirteen Western States and three Territories, converting this into a fund in the Treasury of the United States to be utilized in the construction of works for the reclamation of arid lands, these lands, if public, being given away to men who will live upon them, payment being made for the actual cost of bringing water to the land. The repayments for this water are turned back into the Treasury and become immediately available for the construction of other works.

In short, the Reclamation Act creates a revolving fund which, if well administered, should grow continually, to be utilized until all of the arid lands of the West have been reclaimed.

The estimated funds from 1901 to 1908 amount to a little over $40,000,000. Plans have been made for the investment of this entire amount and work begun on large structures at various points in the arid West. About twenty-four projects have already been begun, after approval by the Secretary of the Interior, who is the official charged by law with putting the Act into effect.

To assist him in this matter the Secretary of the Interior has what is known as the Reclamation Service, an organization of about 500 skilled engineers and assistants. These men have studied the situation, made surveys and preliminary designs, and after these have been approved by the Secretary of the Interior, have begun work of construction, the operations in general being carried on by contract in the customary manner. It has been found, however, that the price of material and labor has advanced so greatly within the last year that many of the contractors have

been financially embarrassed or have failed. As a result it has been necessary for the Government to take over the works and complete them by what is known as "force account." In the case of other large works, bids for which were asked, there have been no bidders, or the prices offered have been so high as to render it impracticable to award a contract. In such cases the Secretary of the Interior has authorized construction by force account, it being ascertained that this can be done by the present organization, as a rule, cheaper than by the usual form of contract. The conditions are somewhat anomalous; but with a rising market for labor and material it becomes exceedingly difficult for even the best equipped contractor to make estimates which will allow him to realize a profit, especially when the work is carried on through several years.

One of the features of the Reclamation work to which especial care has been given is that of cost keeping, not only to ascertain the total cost of the work, but also the unit cost of each important operation. These costs are kept not only for the work which the Government itself is carrying on by force account, but also for the contractor, so that it is possible to compare the actual cost of the work to the contractor and to know from time to time whether the contractor is making or losing money. This is an important detail in any Government work of this character, as the responsible men in charge should know whether the contractor is in a financial condition such that he can bring the work to a successful conclusion. Otherwise, plans must be made for taking over the work, if the contractor will not be able to push it successfully.

It is also important that the Government and the people interested know exactly what the work is costing, so that there may be no misapprehension on the part of any one as to the ability of the Government to handle its own work by a thoroughly trained civil service. It is believed that the results accomplished demonstrate this fact, namely, that it is possible by careful selections under civil service laws to obtain men of high character and ability and by the promotion of these and recognition of their work to create an organization capable of handling Government work economically and effectively.

The following brief statement gives the larger features of each of the projects in the various Western States and Territories.

These are arranged alphabetically by the name of the State. It should be pointed out that each project differs from all others and that each offers peculiar problems difficult of solution. One of the greatest obstacles to be overcome in the organization of the Reclamation Service is due to the fact that the work is so widely distributed that it is practically impossible for one man to see all of the work even if he should travel continuously for nearly a year. It has thus been necessary to select for supervising engineers in the field men of large ability and to give these men discretion in detail such as would hardly be given to subordinates in

Site of the Roosevelt dam, Arizona.

the case of works which are concentrated within the limits of one State or which could be reached within a few hours' travel.

In this respect the difficulties met by the Reclamation Service are more extreme than those at Panama, where the work can all be inspected within reasonable time and where it all lies on a railroad and covers an area of about forty miles only in extent. Many of the Reclamation projects with regard to area are far larger, some of them extending for a length of nearly a hundred miles and without railroad facilities.

Arizona.—The Salt River project contemplates the construction of a large storage dam, 270 feet in height, at Roosevelt, Ariz., which will regulate the supply of water by gravity system for about 160,000 acres of land in the vicinity of Phœnix. When the dam is constructed there will be developed a large amount of power, which will be utilized to increase the water supply in the Salt River Valley by means of pumping from underground sources.

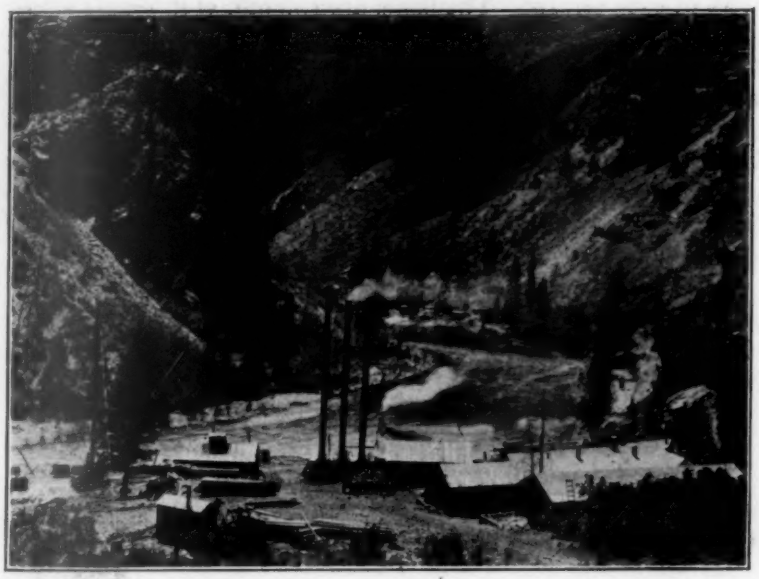
A cement mill was erected by the Government and is now in operation, furnishing a first-class quality of cement to be used in the works. The construction of the dam will require 200,000 barrels of cement. The lining of the power canal and the work on the sluicing tunnel are finished, and the work on the large dam is being pushed.

California.—The Yuma project is for the diversion of the waters of the Colorado River, by means of the proposed Laguna dam and sluiceways, about ten miles northeast of Yuma, Ariz., into two canals, one on each side of the river. In Arizona these canals will irrigate all the bottom lands of the Colorado and Gila rivers, between the Laguna dam and the Mexican boundary (84,000 acres in round numbers), and in California the bottom lands in the Yuma Indian Reservation (17,000 acres). Plans also contemplate the construction of a complete system of levees to protect the bottom lands from overflow and a pumping system to remove the surplus water from the low-lying areas.

Colorado.—The Uncompahgre Valley project contemplates the diversion of waters of Gunnison River by means of a tunnel 30,000 feet in length, cross section 10½ by 11½ feet, cement-lined, capacity 1,300 second-feet. The tunnel passes under a high divide and carries the water to Uncompahgre Valley, where it will be utilized for the reclamation of 140,000 acres of land in Montrose and Delta counties. Construction of the tunnel was begun in 1904 and work thereon has since been progressing rapidly. More than 3½ miles are completed.

About twenty per cent. of the irrigable land is subject to homestead entry under the provisions of the Reclamation Act. The farm unit for first-class fruit land will probably be forty acres, while on other lands suitable for growing grain, sugar beets and alfalfa eighty-acre tracts may be filed upon. No water can be delivered for irrigation prior to the crop season of 1909.

Idaho.—The Minidoka project provides for the reclamation of about 130,000 acres of land lying on both sides of Snake River in Southern Idaho. The area to be benefited was all Government land, which has been withdrawn from general entry under the provisions of the Act of June 17, 1902, but remains subject to entry under the provisions of the Homestead Law. Homestead entries within a radius of 1½ miles from the center of each town site established are limited to forty-acre tracts, and those on all other lands under this project to eighty acres. The soil is excellent, being a deep, sandy loam free from alkali, now produc-



Gunnison Run, at head of tunnel taking water into Uncompahgre Valley, Colorado.

ing a thrifty growth of sagebrush. The cost of water right under this project will be $25 to $35 an acre, to be paid in ten annual installments, without interest. It is believed that all of the land is now filed upon by bona fide settlers.

The large dam is completed; the telephone system is finished, and work on the distributing system is being pushed vigorously. Present conditions indicate that water will probably be turned on the lands under the gravity canals in the irrigating season of 1907.

The lands to be included under this proposed system are tributary to the Oregon Short Line Railway, which has recently extended a branch line through the Minidoka tract, upon which are located three town sites, the lots in which are offered for sale by the Government.

The Payete-Boise project ultimately will reclaim about 370,000 acres of land in the valleys of the Payette, Boise and Snake Rivers, in Southwestern Idaho. Of this area about five-sixths is without present facilities for irrigation. The complete plans propose the utilization of both the Payette and Boise Rivers and include the construction of extensive storage works at the headwaters of each stream. The lands are smooth, with gentle slope to drainage. The work of construction has been taken up by units and several years will elapse before the whole project is completed. Several contracts have been let and the work is now under way.

Kansas.—The Garden City project, by means of an extensive pumping system, will provide a supply of water to irrigate about 8,600 acres situated just east of Deerfield, in Southwestern Kansas. The land in question is all in private ownership and is under an existing system owned by the Finney County Farmers' Irrigation Association. The attempt to furnish water for the irrigation of these lands by a gravity system supplied by diversion from the river has not met with success, owing to the rapid loss of water from the river to the gravels and the uncertain volume of flow in this stream.

The proposed pumping plant is designed for the recovery of underground waters and involves the construction of twenty-three separate pumping stations, each driven electrically from a central power station.

Montana.—The Huntley project is one for the reclamation of about 30,000 acres of land located along Yellowstone River in Southeastern Montana, within the ceded portion of the Crow Indian Reservation. The lands to be reclaimed are along the Northern Pacific and Chicago, Burlington and Quincy Railroads. They form a portion of the area which the Crow Indians, by treaty ratified by Act of Congress approved April 27, 1904, ceded to the United States. Upon the completion of allotments to the Indians as required by the act, the area remaining is to be subject to disposition in accordance with the provisions of the home-

stead laws and the rules and regulations governing the disposal of public land. In addition to the cost of reclamation, the price of the lands is to be $4 an acre when entered under the homestead laws.

The *Sun River* project was formally approved by the Secretary of the Interior on March 19, 1906, and the sum of $500,000 was allotted for initiating the work of construction. The preliminary investigations indicate that in the Valley of Sun River 256,000 acres are reclaimable, a large percentage of which is public domain. The irrigable area is a broad prairie extending from Teton River on the north to Sun River on the south, a distance of thirty miles, and from the Rocky Mountains on the west to Missouri River on the east, a distance of seventy miles.

This land, although extremely rich in all the elements of fertility, without water is only fit for grazing, but when irrigated will be very productive. The examinations made by the engineers show that this project is free from difficult engineering features, and the topography of the country is such that it can be built a unit at a time. It is possible that the first unit selected for construction will be the reclamation of about 16,000 acres.

Nebraska-Wyoming.—The North Platte project has for its object the storage of the flood and surplus waters of North Platte River in a reservoir in Wyoming by a dam 210 feet high in a narrow canyon just below the mouth of Sweetwater River. During the irrigating season the water will be permitted to flow down the channel of the river for about 150 miles to where a low diversion dam will turn it into canals, which will distribute it over the lands to be irrigated.

The land to be reclaimed is fertile and adapted to the successful growth of a wide variety of crops. Water will be delivered for the irrigation of a considerable portion of the land under this project during the season of 1907.

The Pathfinder tunnel has been completed and contracts have been let for the construction of the Pathfinder dam, for the excavation for about ninety-five miles of the Interstate canal, and for re-enforced concrete structures on its first forty-five miles.

Nevada.—The Truckee-Carson project, when completed, will provide an ample supply of water to irrigate about 350,000 acres of arid land in Western Nevada. The first work of actual construction was begun in September, 1903, on a canal thirty-one

miles in length, to divert water from Truckee River and convey it to the channel of Carson River, where a storage reservoir will eventually be built. This canal, with several hundred miles of lateral ditches, is completed, and on June 17, 1905, the third anniversary of the Reclamation Act, occurred the formal opening of this project, the first to be constructed under the authority of the law of June 17, 1902.

Water is ready for delivery to more than 100,000 acres, the greater part of which is public land, which has been thrown open to homestead entry, and may be filed upon by bona fide settlers, in accordance with the rules and regulations of the homestead laws, and Reclamation Act. An assessment of $26 per acre will be charged against the land for its water right, payable in ten annual installments, without interest.

The construction of outlet and regulating works at the outlet of Lake Tahoe and the extension of the system to include additional areas will be undertaken at an early date.

New Mexico.—The Hondo project, completed in 1906, diverts and stores the water of Hondo River, a tributary of the Pecos, and will make possible the reclamation of about 10,000 acres of land in the vicinity of Roswell.

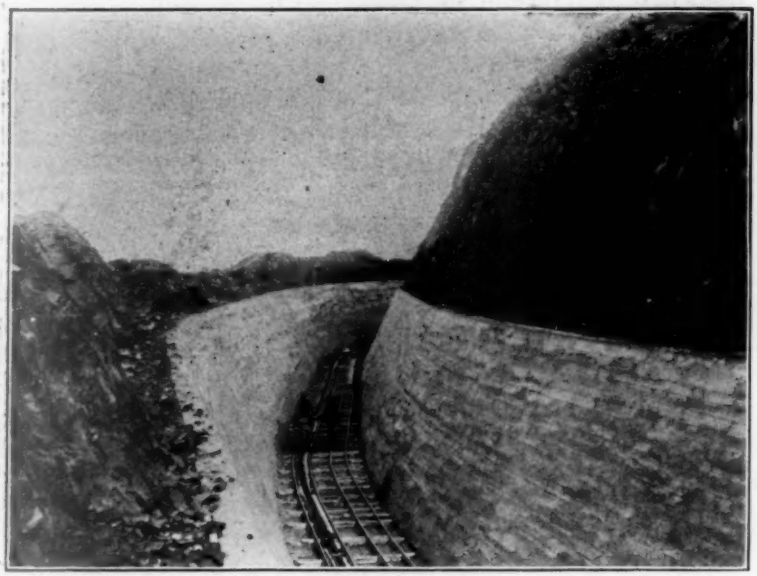
The Carlsbad project includes storage reservoirs in Pecos River in Chaves County and the extension of canals which have been constructed by private enterprise to irrigate about 20,000 acres of land. The development of Pecos Valley has been brought about by individuals, who installed an extensive system of irrigation works, representing the outlay of more than a million dollars. On October 4, 1904, a flood in Pecos River destroyed a large portion of Avalon dam, upon which the canal system depended for its supply. The owners of the canal system were unable to repair the damages, and, as property valued at not less than $2,000,000 was threatened with destruction unless the water supply was provided, an appeal was made to the Government to take the works and to initiate construction in order to prevent the destructions of homes and property. Construction has been begun. The land under this project is now mostly in private ownership.

New Mexico-Texas.—The Rio Grande project involves the construction of a storage dam opposite Engle, N. Mex., across the Rio Grande, which will form a reservoir 175 feet deep at its

lower end and forty miles long, with a storage capacity of 2,000,000 acre-feet, for the irrigation of 180,000 acres of land in New Mexico, Texas and Mexico.

The Leasburg division, which is a part of the Rio Grande project, calls for the construction of a low 500-foot concrete diversion dam, with pier, embankment and sluice gates, head weir, and head gates. In connection with the diversion dam it will be necessary to construct six miles of full-size canal to connect with the old Las Cruces canal.

North Dakota.—Three pumping projects are planned in West-



Complete portion of concreted lined canal through rock cut on Truckee Canal Nevada.

ern North Dakota for the purpose of raising water from the Missouri River to irrigate bench lands which lie at heights too great to be reached by gravity systems. Both steam and electric power will be used for pumping, the power to be developed from lignite coals which are found in ample quantities near by.

Buford-Trenton project.—This project, located about twenty miles west of Williston, on the Great Northern Railroad, will supply water for a series of flats aggregating about 27,000 acres.

Williston project.—The pumping plant for this project will be located about five miles west of Williston and about twenty-five miles east of the Montana-North Dakota State line. Forty thousand acres of bench land on the north side of the river will be irrigated, but the system is capable of extension to flats on the other side of the river, making a total of approximately 70,000 acres. It is proposed to pump all the water required from the Missouri River into the low-line canal at the main plant, and to pump from this main canal into canals at higher elevation by means of electrically operated plants conveniently located.

Nesson project.—The area to be covered by the Nesson project consists of about 25,000 acres of bench land situated thirty miles east of Williston, the larger part being on the north side of the Missouri River. About twenty-five per cent. of the land is in Government ownership.

North Dakota-Montana.—The Lower Yellowstone project takes water from Yellowstone River at a point seventeen miles northeast of Glendive, Mont., for the irrigation of 66,000 acres of land lying in Northeastern Montana and Northwestern North Dakota. Work is in progress on the main canal and lateral system.

Oregon.—The Umatilla project embraces 20,000 acres immediately south of Columbia River and east of Umatilla River. About ten per cent. of these lands are in public ownership. The engineering work in connection with this project consists of a feed canal from Umatilla River to the Cold Springs reservoir and a distribution system. The works are of simple character and capable of being constructed in a short time. The irrigable area under this project lies below 500 feet in altitude, is rolling in character, and the lands are of high fertility. The climate is warm and the soil adapted to orchards, small fruit and vegetables.

Oregon-California.—The Klamath project lies across the State line in Southern Oregon and Northern California. The total irrigable area under this project embraces 236,402 acres, of which forty-five per cent., or 106,829 acres, is public land, and 55 per cent., or 129,573, is private land, 90,000 acres being in California and the remainder in Oregon. The lands are of excellent quality, and alfalfa, wheat, oats, barley, rye, vegetables and the deciduous fruits are grown successfully. Experiments in the culture of sugar beets show that this crop may become a

profitable industry. The project naturally falls into two distinct parts—the so-called "upper project," provided for the irrigation of lands in Langells, Yonna, Poe and upper Klamath Valleys, and the "lower project," which includes the irrigation of lands in Klamath and lower Poe Valleys, and the reclamation of lower Klamath and Tule Lakes by drainage.

Contracts for the construction of the main canal and the auxiliary works have been let and construction of the system has begun.

South Dakota.—The Belle Fourche project, when completed,

Dam and headgates, Truckee River, Nevada.

will reclaim about 100,000 acres lying northeast of the Black Hills, Butte and Meade Counties, S. Dak. Of the total irrigable area it appears that about 50,000 acres is public or Government land.

Work on the main supply canal, the dam, and distributing canals is progressing steadily. It is expected that the south side canal, which will furnish water to irrigate about 20,000 acres, can be constructed in time to deliver water in 1907.

Utah.—The Strawberry Valley project provides for the irrigation of about 50,000 acres of land in Central Utah, situated from

five to fifteen miles south of Provo and on the eastern shore of Utah Lake. Water supply will be received from a storage reservoir to be built on Strawberry River, about thirty miles east of the irrigable area. By means of a tunnel four miles long the stored waters will be carried under the divide and emptied into Spanish Fork, from which a canal from eighteen to twenty miles long will convey them to the irrigable area. The lands have a mean elevation of 4,500 feet.

Washington.—The Okanogan project is designed to supply water to 8,650 acres of land in Okanogan Valley, in Northern Washington. The water supply is estimated to be sufficient for the proper irrigation of 10,000 acres, 1,350 of which are now supplied. The farm unit has not been definitely fixed, but a soil survey is being made, and it is believed that on account of the possibilities for high development in this section the area allowed each settler will be restricted to forty acres.

Yakima Valley contains an area of approximately 500,000 acres; with storage it is estimated the water supply is sufficient for 340,000 acres. This acreage includes approximately 100,000 acres in the Yakima Indian Reservation, which can be brought under canals at a moderate cost, but for which there is no late summer flow in the river. The development of a comprehensive system of irrigation in Yakima Valley can be accomplished by the successive construction of several units of a general project, the work being graduliay extended to embrace the entire irrigable area.

The Tieton division, which is an integer of the great work projected in Yakima Valley, embraces an area of about 24,000 acres west of and near the city of North Yakima. The water supply will be from Tieton River, supplemented by waters stored in Bumping Lake.

The Sunnyside division of the Yakima project contemplates the enlargement and extension of the Sunnyside canal system now in operation, and in connection therewith the construction of suitable storage works at the upper Yakima Lakes. The canal and lateral system contemplated as the first section of the work will irrigate about 40,000 acres of land. Construction of the Tieton and Sunnyside projects will begin in the spring of 1907.

Wyoming.—The Shoshone project provides for the diversion

of a portion of the waters of Shoshone River, and the construction of an impounding dam at the head of the canyon through which the river flows. The reservoir thus created will have a

Shoshone Dam Site, Wyoming.

storage capacity of 456,000 acre-feet. When the project is completed, it will be possible to reclaim about 175,000 acres of irri-

gable public lands. A portion of this area, 122,000 acres in extent, is located on the left, or north side of the river, and 53,000 acres on the right, or south, side, the whole being about seventy-five miles east of Yellowstone National Park, Wyo.

The soil is productive, and hay, wheat, oats, barley and the hardier vegetables can be produced abundantly with an ample supply of water. At the proper time, when the construction of the project is approaching completion, the lands will be thrown open to homestead entry by bona fide settlers under the homestead laws and terms of the Reclamation Act.

Construction work is well under way on the outlet tunnel, temporary diversion works at the dam, and Corbett tunnel.

THE AMERICAN GALVANIZING COMPANY.

A company is now being formed by H. W. Poor & Co., 33 Wall street, New York, named the American Galvanizing Company, for the purpose of introducing in this country the process of dry galvanizing which is known as Sherardizing. This new process of galvanizing is in successful use in Great Britain and Germany, and has received considerable attention in the technical press. In this process the articles to be galvanized are placed in a closed iron receptacle filled with zinc dust and heated to a temperature of 500 to 600 degrees F. (200 to 300 degrees below the melting point of zinc) for a time varying from a few minutes to several hours, according to the size of the article treated, and are then allowed to cool. The articles treated are then found to be coated with a fine homogeneous covering of zinc, the thickness of which is dependent upon the temperature and the time for which the article has been treated. The covering effected in this manner is not merely superficial, but is claimed to be alloyed into the surface of the article treated. It is then impossible to separate the zinc either chemically or mechanically without removing the original surface of the article treated. It is claimed that by this process the required plant is much cheaper than a plant for hot galvanizing; a great saving in fuel and labor is effected; a less amount of zinc is required; a coating of any desired thickness can be given; the surface is much smoother; a high polish equal to nickle plate can be given at very little cost; there is no loss in temper or of tensile strength; screws do not require to be rethreaded after treatment; large articles, such as structural shapes, can be treated.—*Iron Age.*

(*Stated Meeting held Wednesday, November 21, 1906.*)

The Why of the Weather.

HARVEY M. WATTS.

[ABSTRACT.]

Mr. Watts, with the aid of lantern slides, showing weather maps, storm tracks and the general circumpolar weather drift, as well as photographs of the Blue Hill Observatory connected with Harvard University, where the sounding of the ocean air by means of kites has been carried on so successfully for over ten years, and the new Mount Weather Observatory of the United States Weather Bureau, of which so much is expected, developed the general theory now held by leaders in the meteorological world as to the cause of variations in weather and climatic conditions.

Mr. Watts pointed out that the science of meteorology was on the verge of a great advance; first through the possibility of a general daily survey of pressures the world over, which would allow a synoptic chart of the entire northern hemisphere to be made; and, secondly, through clearer understanding of the relation of variations in the sun's radiation to seasonal changes in terrestrial weather and climate.

The general synoptic chart giving pressures for the northern hemispheres naturally would be the first step toward extending daily forecasts so as not only to cover twenty-four hour periods, but forty-eight hour periods and even periods of a week or more. This would be possible since the weather drift in the northern hemisphere above the tropics being eternally from West to East, in a great circumpolar swirl, the position of storm-tracks and their intensity depends entirely on the intensity of the travelling barometric pressure centres interacting with variations in the extent, intensity and location of the so-called permanent areas of high and low pressure. Once the pressures and all the meteoro-

logical elements all over the circumpolar area north of latitude 30 are known, the weather to the eastward of any given condition can be predicted with more or less accuracy for several days and on special occasions for relatively long periods.

For instance, a more accurate knowledge of the pressures lying over Siberia, China, the mid-Pacific and Alaska, in connection with the pressures over India and Eastern Europe, would enable one to make very much more accurate forecasting for the United States, since the movement of the traveling areas of high barometric pressures (anti-cyclones) and low barometric pressures (cyclones)—the two eddies into which the general circumpolar drift breaks up—eastward over the United States, is determined by these antecedent conditions lying west of the Pacific Coast.

The subsequent pathway across the United States, and later toward Western Europe, is due to a further interaction with the permanent areas of high pressure lying over the Atlantic. And again, the extent and position of this Atlantic anti-cyclone is in turn a resultant of the interactions of pressures further eastward. It is this inter-dependence of pressures, which condition weather the world over, that makes a synoptic chart of the whole northern hemisphere so important a basic condition of any improvement in weather forecasting for periods within a week or less.

As to improvements in seasonal forecasting, with anticipations of the climatic variations, which are such constant features of the seasons in the north temperate zone, Mr. Watts showed that this long range forecasting of seasons could only come through a study of the variations in the solar radiations, which variation was to be the subject of research at the superb observatory which the United States is building on the top of the Blue Ridge on Mount Weather, Virginia.

The speaker said it must be clear to any one who gave the matter thought that if the sun's radiant output were a constant, with the land and water masses of the earth being what they are now from all historic periods, the variation in climatic conditions from year to year should be insignificant. As a matter of fact, however, we know that the variations are often of an extraordinary character. In any one given year, for instance, the central regions of the United States might experience a summer of extraordinary dryness and intense heat, while the next year the very same region might experience a cool and wet summer or a cool

and dry summer, or any combination possible in weather conditions.

Mr. Watts pointed out that the hot summer type was due entirely to an increase of the pressures in the sub-tropics, south of thirty degrees of north latitude. A summer of this type in the United States meant a strong persistent circulation of air from the South with the interiors baked under excessive sunshine and hot sirocco winds which have been known to blast vegetation in twelve hours. The relation of such contrasts in seasons to the solar variations, he declared, was being worked out by a number of specialists, among them being Prof. F. H. Bigelow, of the United States Weather Bureau, and he said in general the belief which was obtaining credence among meteorologists was that not only must the variation in the quantity in the solar radiation be taken into account, but a variation in the quality, in the matter of its electrical and magnetic as well as mechanical effects.

The way in which the solar variations affects seasonal changes is seemingly through a variation of the intensities of the sub-tropical pressures. With the sub-tropical pressures strong the south to north circulation tends to rule the northern hemisphere, while when the sub-tropical pressures are less intense the tendency is for the north to south circulation to be more insistent, the paths of the traveling cyclones and anti-cyclones coming further south in both the winter and the summer, with consequently marked variations in what are known as the seasons and also marked changes in the local weather phenomena.

Mr. Watts then called attention to the character of the research into the upper levels of the atmosphere, which play an important part in the questions of the variation of pressures, temperatures and moisture and the formation of rain and general storm and clear weather phenomena. Pictures of the kite flying at Blue Hill, where self-recording instruments were carried over fourteen thousand feet in the air, were shown, as well as pictures of the balloons used at Mount Weather for sounding the air, along with pictures of the Administration and Magnetic Buildings now in use at the Mount Weather Observatory. The Magnetic Buildings at Mount Weather are the most perfectly equipped in the world, Prof. Willis L. Moore having profited by the experiences of other countries, and having adopted and improved upon the instruments in use elsewhere.

It is through studying the variations in the magnetic field of the sun, along with the physical changes going on there, that the correlation between changes in the sun and changes in the weather and climate on the earth will be worked out. As things went, the speaker looked for a great advance in the solution of meteorological problems along the two lines laid down by him, better forecasting for short and long periods and a firmer grip on the cause of variations in climate from year to year.

THE WORTH BROS. COMPANY, Coatesville, Pa., recently rolled in one of its plate mills eighteen copper ingots, each weighing 6300 lbs., into plates 122x216½ in. and 63-100 in. in thickness. These plates were rolled for the Baldwin Locomotive Works, Philadelphia, Pa., and are the first plates of that kind ever rolled by the company. It is understood that they will be used to line boilers of locomotives, which are being made for export to France. Eighteen more plates of the same size will be rolled at an early date for the same purpose.—*Iron Age.*

THE construction of a destroyer, with 30,000 hp. in five gas engines, each propelling a screw, it is announced, is to be started by Lewis Nixon, following the lead of the British Government, which is at present building a destroyer of 1800 tons displacement, to be propelled at a maximum speed of 36 knots, by steam turbines of 30,000 hp. The maximum speed of this new vessel it is said will be 33 knots, while it is announced that a sufficient quantity of fuel will be carried to enable the craft to cross the Atlantic to England at a speed of 30 knots, or in four days. The great difficulty with regard to this part of the programme is based upon the fuel consumption of the engines. Many destroyers are afloat which could accomplish this feat were only this phase of the subject absent. It is stated that in the present case, however, the gas engines, which are each of 6000 hp. (the largest marine gas engine heretofore built is 500 hp.) will be so economical as to make possible the projected transatlantic trip at a speed greater than has ever yet been deemed possible.—*Iron Age.*

THE PRODUCTION of aluminum in the United States in 1906 was 14,350,000 pounds. It is expected that the output in 1907 will be twice as much, and that the output of 1908 will double that of 1907. Aluminum has often been spoken of as a possible competitor of copper, but up to the present time its production has been too small to make it a matter of serious consideration in that respect. However, it appears as if conditions may be different by 1908. Few realize that, outside of iron, steel and copper, perhaps no other metal has the possibilities before it that aluminum has.—*Eng. and Min. Journal.*

Section of Physics and Chemistry.

(Stated Meeting held Thursday, April 25th, 1907.)

A New Color Meter.

By Frederic E. Ives.

It has long been recognized that a universal color meter, capable of measuring all colors and expressing them in numerical terms, must be based upon the principle of Clerk Maxwell's "color box," in which half of a divided field is illuminated with ordinary white light, while the other half is illuminated by an adjustable mixture of the three simplest colors of the spectrum, isolated bands of pure red, green and blue-violet.

Without any alteration Maxwell's color box could be used for measuring the colors of transparent objects, such as colored glasses and solutions, placed in front of the aperture for direct light, but it is not adapted for the measurement of the colors of opaque objects. It is also necessarily a large and clumsy instrument, that used by Maxwell being of elbow form, several feet in length, and with the adjustments for taking measurements of a complicated character and quite out of reach of the observer at the eye slit.

Although many attempts have been made to devise a color box type of color meter to meet the various requirements in the industries, not one of them has proved successful, and manufacturers have found nothing better for their purpose than a "tintometer," which uses purely arbitrary scales, different and distinct sets of which are made for a large number of trade uses.

The new color meter is a direct vision instrument, the body of which is about 3x4x20 inches in size, with all the operating adjustments controlled by screws a few inches from the eye. A low dispersion grating is used in place of the prisms in Maxwell's color box, and the field is so divided as to be illuminated through a central slit for ordinary light on one side, and

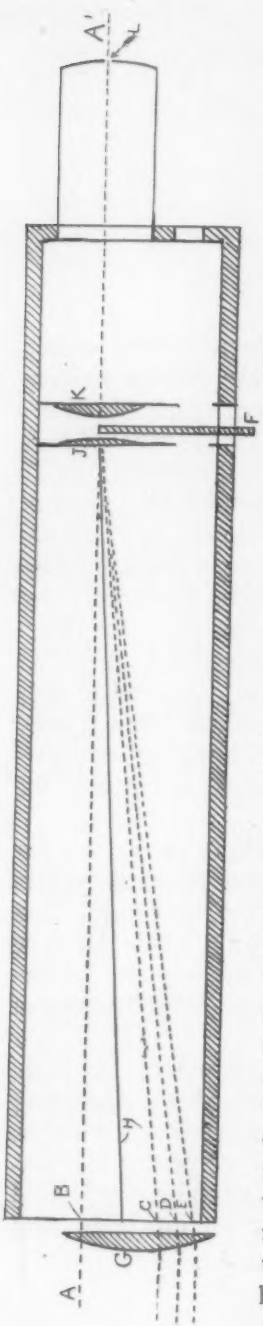


Fig. 1

through three laterally displaced slits for the three-color mixture on the other, while a lens placed in front of the four slit forms an image of external objects which looks like an ordinary single telescopic image divided by a vertical spider line in the eyepiece. The image in the right half of the field is produced in the simplest manner, by light transmitted by the central slit; the image in the left half of the field is formed by mixture of rays transmitted by the three lateral slits, and in using the instrument as a telescope this half of the field would not appear illuminated at all but for the presence of the diffraction grating, which bends parallel to the axis blue-violet rays from the first lateral slit, green from the second, and red from the third, the mixture matching the ordinary white of the right side of the field.

Assuming that the instrument is directed to a surface of standard white, over a portion of which is placed a sheet of colored material to be measured, it will be evident that by so directing the telescope that the colored object fills the right field just up to the dividing line, the left field can be made to match it both in hue and luminosity by suitably reducing the apertures of the color slits. These slits are ruled in a dividing engine, through an opaque film on glass, covered for protection by the thinnest microscope cover glass, and closed by sliding brass plates which are controlled by micrometer screws. Theoretically, the slits should close from both sides towards the middle; but that is a quite unnecessary refinement of adjustment for this instrument. Each micrometer screw head carries a pointer which moves over 100 divisions of a concentric scale to

fully close or open the respective slit, thus reading to one per cent. The scale numbers are read off when the two halves of the field match in hue and luminosity, and recorded as 50 R, 20 G, 60 B, or whatever it may be, as a numerical expression of the color of the object.

Should the shape of the colored object be irregular, the insertion of a thin prism in front of the central slit will displace the image laterally so that a portion at some distance from the edge of the object will come to the inner edge of the divided field, without invading the color mixture half of the field. Very small transparent objects, such as bits of colored glass, solutions in flat glass cells, etc., are placed directly in front of the central slit, and thus made to fill the right field.

The use of a grating in place of prisms in a color meter is believed to be quite new. By no other means would it be possible to make a compact direct vision instrument with a sharply divided field in which one half of an image formed by a single objective is obtained directly through laterally displaced slits, and no other means would permit of such simple and convenient mechanism for taking the measurements.

The obvious objection to a grating is that the conventional type of opacity grating throws a great deal more light into the central image than into any of the spectra, and as only one of the spectra is utilized the illumination would be very much more feeble than with a prism; but it is not necessary to use a grating of this type. Thorp demonstrated the possibility, though not the commercial practicability, of making gratings which throw nearly all of the light into a single spectrum on one side, and the writer can make to order gratings which throw more than 50 per cent. of all of the transmitted light into the first order spectra. It is a grating of this character which is used in the new color meter, with entirely satisfactory results. Many things which have had to receive careful consideration may be best understood after a more detailed description of the perfected instrument and its operation has been given.

Fig. 1 is a vertical plane of the optical part of the diffraction color meter. A, A^1, is a line drawn through the optical axis; B, is the central slit for ordinary light; C, D, E, the lateral slits for blue, green and red spectrum rays; F, the grating, covering half of the field; G, a telescope objective which forms

an image of external objects and background in the divided field; H, a diaphragm to cut light from the central slit out of the half of the field covered by the grating. The lens, J, is of such focal length as to exactly parallelize rays from the central slit B, and the lens K, to converge them to the eye slit at L, from which the field is seen evenly illuminated.

The slits and slit mechanism are all on the outside of the case, and adjusted by micrometer screws acting on levers, conveniently close to the eye. The levers are short and rigid, with a lateral extension and support, because they must work without any wobble or backlash. The obvious method of construction would be to have the micrometer screws act directly upon the slit slides; but that would bring them too far from the eye for convenience of operation, and would also necessitate the use of special differential scales. The use of levers permits of adjustment for different total apertures by simply sliding the micrometer screw mount along the arm of the lever, leaving the scales all alike. These advantages are of such importance that although I at first experienced great difficulty in devising and fitting lever movements that would be "dead beat," I persisted until I believe I have achieved perfect success.

Inasmuch as the setting of the slits must be accurate to $\frac{1}{100}$ of a millimeter, it would be unreasonable to expect such fixtures to retain their adjustment, and provision is therefore made for quickly testing the adjustment and perfecting it in a few seconds if it proves not to be right as found. This, I am convinced, is a wise provision to make, whatever the character of the mechanism, and it serves in this case to permit of such important reduction of cost of manufacture as might very well make all the difference between success and failure as a commercial proposition.

The slit spacing is calculated to superpose wave lengths 43, 53 and 66 on the image of the central slit at the eye slit, when all three of the color slits are half closed; the measurements are therefore made in definite terms. The absolute aperture of the open slits has been found by trial and error, to make the two halves of the field exactly match on a standard background. This is necessary because the extraordinarily brilliant gratings used do not give a perfectly normal distribution of light

through the spectrum. This adjustment having been made, a position was found for the bearing of the respective micrometer screws which made them exactly close the slits when the pointer was turned from 100 to 0 on the attached scales, thus dividing each slit opening into 100 parts, although the absolute opening is alike in no two. That the instrument is in adjustment can be proved by several experiments, one of which is to partly close the central slit, when it will be found that the three pointers must be turned down the scale equally to match the white or lower luminosity.

If the color meter be now directed to a house across the street, a single image will appear in the field, with a vertical hair line division through the center, and although the right half of this image is formed through the central slit and the left half exclusively by rays passing through the three lateral slits and then bent parallel to the axis by the grating, making a mixture of red, green and blue-violet spectrum rays only, at the eye point, the two halves of the field may appear exactly alike to the eye. Directed to an evenly illuminated standard white background, the two halves of the field appear exactly alike, of an even, neutral white. The light transmitted by the central slit to the right half of the field is matched in the left half by spectrum red (R) 100, spectrum green (G) 100, and spectrum blue-violet (B), 100.

If, now, that part of the background which covers the right half of the field is covered by a sheet of colored paper, certain kinds and quantities of the colored rays filling the left half of the field must be cut off in order to make the two halves match again, and the quantity remaining is a measure of the color and luminosity of the paper in terms of R, G, and B spectrum rays. Assuming that the scales read R 50, G 20, B 60, this color can at any time be reproduced by pointing the color meter at a standard white background and setting the indicators at those figures, provided that at the time it is done all slits exactly close by turning the pointers down to zero, which can be determined by trial in a few moments. If it is now desired to see if a new sample of colored paper matches the old one, which meantime may have been lost or changed color by fading or otherwise, the new sample is placed on the white

ground so as to appear in the right half of the field, and any difference from the old sample will be at once apparent.

There is an aperture in the case at the left of the eye slit, through which the three color slits can be seen directly, and watched while opening and closing to see that the movement is smooth and that they close exactly alike at top and bottom, which they will if the slit slides are in place on their runners and the slit fingers have not been bent. The best way to test the accuracy of their setting for zero is to turn two of the pointers past the zero point (by lifting over the stop) to secure an absolute cut off of light from the respective slits, then turn the remaining screw while looking through the eye slit. The field should just go black when the pointer is turned down to zero, and then show a trace of light when turned up two divisions on the scale. If it does not, hold the pointer to zero and adjust by turning (with a screw driver) the inside pin screw. Test the other two slit adjustments in the same way. The adjustment may stand true all day, but temperature changes are liable to affect it. The image of the central slit must also fall exactly in the middle of the eyepiece slit. This can be determined by looking at the eye slit through a small magnifier, provided for this purpose, and if readjustment is necessary it is effected by a slight lateral displacement of the eyepiece slit.

A point which may be noted about the reading is that the difference between the highest scale number and 100 represents black, and the difference between the lowest scale number and zero represents white. Thus the reading R 50, G 20, B 60, indicates 40 per cent. black and 20 per cent. white, degrading a hue which is three parts of red to four of blue. While considerations of this nature are interesting, and have their uses, the simple numerical expression R 50, G 20, B 60, serves every purpose for record and reproduction.

While the description which I have given will doubtless serve to make the operation of the new color meter sufficiently clear, the subject is far from being exhausted, and I cannot close without discussing briefly some other pertinent matters.

In the first place, in order to make measurements having a high degree of precision, the spectrum colors with which the measurements are made must be taken from the right places in the spectrum, and in sufficiently narrow, isolated bands. This

is determined by the focal length of the collimating lens, the dispersion of the grating, the spacing of the slits, the width of the color slits, and the width of the eye slit. In this instrument, the spectra at the plane of the eye slit are nearly one cm. long, and so pure that the Fraunhofer D, E, and F lines look sharp under a two and a-half inch magnifying glass when the R slit is one-third open, and the G and B slits half open. Practically, therefore, the degree of purity and isolation of the spectrum colors depend chiefly upon the width of the eye slit, which determines how wide bands of the substantially pure spectra shall enter the pupil of the eye. The eye slit is 1 m.m. wide, and therefore pretty sharply defined bands of spectrum color are utilized, each not much more than one-tenth as wide as the entire spectrum. In determining a standard for this adjustment, two factors had to be taken into account, namely, aperture of field and luminosity of image,—the first on account of the yellow spot in the retina, and the second because the illumination may be either too weak or too intense to favor a high degree of accuracy in making observations. The shorter the focal length of the field lens, the larger angle the field subtends to the eye, and the smaller the spectra projected at the eye slit. The smaller the spectra at the eye slit, the narrower that slit must be made to secure a given degree of purity of spectrum hue. The narrower the eye slit, the feebler the illumination. If the field subtends too small an angle to the eye, too much of the image falls upon the yellow spot of the retina, which, while it is the best part of the eye for distinct vision, is comparatively insensitive to peacock blue spectrum rays, and makes a high degree of accuracy of measurement out of the question, especially as this yellow spot varies greatly in size and depth of color in different individuals. The image on the retina must be large enough to cover a considerable area outside the yellow spot, and this is first of all provided for. If the illumination is too feeble, the sense of color is not sufficiently excited, as witness colored objects seen by moonlight. If the illumination is too intense, it destroys the sensitiveness of the retina; and this is so far true that Sir William Abney requires a rest of the eyes in darkness for some minutes before making eye tests with his color patch apparatus. With six-inch focus

field lens, 1½ in. in diameter, and 1 m.m. eye slit, the field is large and well illuminated.

In short, to meet practical requirements, certain compromises have to be made; and if they are made intelligently, with a full comprehension of the nature and relative importance of all the factors involved, the result will be, and in this case is believed to be, worthy of acceptance as a permanent standard.

The analysis colors must be just pure enough so that the purest reds, greens and blues that are met with in the arts and industries can be perfectly matched,—the deepest ruby, green and cobalt glasses, and deep shades of the most brilliant coal tar dyes, particularly the violet purples. There was no difficulty about the purest blues and greens that could be obtained, but in order to match certain reds and aniline violets I had to take my red slit further towards the end of the spectrum than would be necessary with a narrower eye slit, and then to make the red slit wider than the others in order to make a white of the mixture. The practical efficiency of the combination finally adopted was proved by careful tests with coal tar colors in combinations adjusted to show narrow transmission bands in the spectroscope, but not until the slit fingers had been very accurately fitted and the inside of the case specially lined and diaphragmed to prevent any scattered light from reaching the grating.

The theoretically higher degree of accuracy which might be attained by sacrificing all considerations of commercial expediency would therefore never be detected in using the instrument for those purposes for which it is designed, and for which it is certainly far more accurate than any device which involves the multiplication of reflecting surfaces to secure increased absorption. In this connection, it may be pointed out that two pieces of pot colored glass, the sum of whose thickness is two m.m., have not the same value as one piece two m.m. thick, and the diffraction color meter will measure the difference by several degrees of scale.

Admitting that one of these instruments is calculated to meet every practical requirement, there remains only the question whether exact duplicates of it can be made with certainty, so that there shall be no doubt about the readings of different instruments being alike. The gratings are all casts

from one original, exactly alike, permanent and unchangeable. The slits are ruled on a standard make of dividing engine, with definite settings and feeds, and are also exactly alike, permanent and unchangeable. Other parts are made to gauge, and the only thing that would be likely to introduce any error is want of uniformity in the focal length of the lenses used. They are made to order and supposed to be alike; if they are not, and the error is small, it suffices to see that the extension of the eyepiece is right to make the image of the slit and spectra focus exactly on the plane of the eye slit, and wave lengths 43, 53 and 66 from the color slits will then superpose in the middle of this slit, as required.

It is necessary to state that because there is a perceptible change of luminosity of each analysis color in passing from one edge of the eye slit to the other, the field must be viewed with the eye slit crossing the pupil of the eye centrally. This is insured by bringing the eye back to a point where the right and left edges of the field are slightly and equally cut off from view by the edges of the slit.

There is still one other point which I must touch upon, though very briefly, and that is the relative facility and accuracy with which different individuals may be expected to make color measurements with the instrument. Much will, of course, depend upon the practice, but after a few hours' practice pretty accurate measurements should be made and verified by repetition in from one to five minutes, provided that the operator has normal color vision. Color blindness, even in small degree, is fatal to accuracy. Even the normal eye is very much more sensitive to percentage changes in some hues than others, and it is well to know that small errors are apt to occur by reason of such known facts as that two per cent. of any color may be added to a perfectly neutral white without being recognized as color. Such limitations are introduced by the eye, and may not be charged up against the color meter.

The purest colors can be matched the quickest. For instance, a very deep and pure red, obtained by combining screens of aniline violet and yellow, is matched by closing the blue and green slits completely, and then moving the "red" pointer down the scale until the luminosities match. It can be done with considerable precision in four or five seconds. On

the other hand, if the red is of a slightly orange hue and at the same time not of very high luminosity, it is difficult to get exactly the right minute proportion of green and make both hue and luminosity match. Pale shades of purple reds are rather difficult, balancing the red and blue with just the right amount of green and in the right quantities to match both hue and luminosity. All kinds of greens, blues and yellows, strong or weak, are comparatively easy to match.

Something should be said about standard white backgrounds, but I have not yet done much with that part of the subject, and will now merely state that for transparent objects nothing could be better than a sky background when it is raining or foggy.

In conclusion, I would point out that the same instrument, with sunlight or electric arc focussed exactly on the eye slit, becomes a perfect projection color patch apparatus, much more convenient than anything heretofore used for that purpose. I have, however, devised a modification still better adapted for that particular purpose, with increased illumination by use of both right and left spectra, and this device will be the subject of another paper.

STRAWBOARD WASTE.

A recent publication of the United States Geological Survey that should have wide circulation in the States where strawboard is manufactured is a paper entitled "The Prevention of Stream Pollution by Strawboard Waste." The author is Mr. Earle Bernard Phelps.

The total waste discharge into the streams in 1900 amounted to 10,239,710,000 gallons of liquor, containing 184,777,382 pounds of straw and mineral matter and 77,191,660 pounds of lime. This enormous waste was discharged by fifty-nine plants of various sizes, but as most of these mills are along small streams the resultant pollution is very apparent.

Experiments conducted in the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology show that 93 per cent. of the suspended organic solids and 98 per cent. of the total suspended matter determined as turbidity can be removed, after a short period of sedimentation, by filtration of the liquor through sand, without coagulants. The present method, that of sedimentation in large fields, is pronounced unsatisfactory, expensive, and based on a wrong principle. The sludge resulting from the sedimentation tanks is declared innocuous after being pressed. It is said to make good soil and to have some value as a fertilizer.

Section of Physics and Chemistry.

(Stated meeting held Thursday, October 11, 1906.)

A Resume' of the Literature of the N Rays, the N_1 Rays, the Physiological Rays and the Heavy Emission, With a Bibliography.*

GEORGE FLOWERS STRADLING, PH.D.

This paper aims to give a statement of the properties claimed to belong to the N rays, the N_1 rays, the physiological rays and the heavy emission, with a history of the investigations and of the decline of belief in the existence of these rays.

In brief the N rays were believed to increase the brightness of an already luminous phosphorescent calcium sulphide screen on which they fell, while on the other hand the N_1 rays lessened its brightness. Barring certain differences of penetrating power, the physiological rays seemed about the same as the N rays. The heavy emission was held to consist of streams of matter ejected from objects, such as metals and liquids, and to be acted on by the attraction of the earth. It, too, made the phosphorescent screen brighten. Still another type of rays, the N_2 rays, has been discussed by a single writer, Breydel.[60]*

Blondlot discovered the N rays, the N_1 rays and the heavy emission; Charpentier discovered the physiological rays. All were first observed in Nancy. It is from the name of this university town that the letter N is taken as a designation.

In the account now to follow results will be quoted at the valuation of the investigators. No attempt will be made to avoid contradiction of properties claimed. Because of their similarity it will be impossible always to distinguish sharply between the N rays and the physiological rays.

*Numerals above the line refer to the numbers of papers in the bibliography at the end of this article.

In 1902 (Paris, C.—R. Acad. sci., 134, p. 1559, June 30, 1902,) Blondlot published his observation that the brightness of a very small spark increases when X rays fall upon the spark gap. During the latter half of the same year he determined, as he thought, the speed of the X rays, reaching the conclusion that they are propagated in different media with the speed of light in air. His method depended upon noting changes in the brightness of a small spark, and was therefore somewhat subjective in nature. In pursuance of this line of work, there appeared on February 2, 1902, a paper by him, with the title, "Sur la polarisation des rayons X."[26] It marks the beginning of N ray literature; though it contains no word about N rays.

The previous endeavors to polarize the X rays had failed. Blondlot proposed to himself to determine whether they are already polarized when emitted. He saw that the kathode ray and the resulting X ray fix a plane. Either in this plane or else perpendicular to it the X rays might have special properties. In his search for lack of symmetry he tried the small spark of his previous investigations in various positions, and was led to conclude that "The little spark plays the part of analyzer. The beam of X rays has the same symmetry as a beam of polarized light." Moreover quartz and sugar were found to rotate the plane of polarization both of light and of the X rays in the same direction.

Three weeks later he states that polarized light acts on the spark just as the X rays do. (Paris, C.—R. Acad. sci. 136, p. 487, Feb. 23, 1903). A month later he reverts to the X rays, and finds that, by transmitting them through a sheet of mica, elliptical polarization is produced, the tiny spark still serving as analyzer. This means double refraction in the mica, and *a fortiori* simple refraction. A quartz prism was found to deviate the beam, and a lens of the same substance to give a sharply defined image of the anti-kathode from which the rays came. Polished glass reflected the beam regularly, while ground glass diffused it. These facts of reflection and refraction proved that the rays in question were not X rays. Blondlot therefore felt justified in calling this paper "Sur une nouvelle espèce de lumière."[27]

The index of refraction for quartz was calculated to be about 2. Rubens, for his very long wave-lengths, had found the value 2.18. The nearness of these two quantities suggested to Blondlot that his new rays might also be emitted from the Welsbach mantle,

which served Rubens as a source of radiation. In his first paper in May, 1903, he announces that this is in fact the case.[28] Behind a quartz lens four foci were found, corresponding to these indices of refraction 2.93, 2.62, 2.44 and 2.29. The rays acting for an hour on a photographic plate produced no effect, but a difference was got between the two effects obtained by letting the light of a small spark act on the plate once with the rays falling on the spark gap and again without them.

A study of transmission through many substances was made.

Later in the same month Blondlot[29] found still other sources of his rays in a luminous gas flame and in a sheet of iron or of silver heated by a flame. A heated sheet of polished silver gives off plane polarized rays. A covering of soot increases the emission but destroys the polarization. In this paper their discoverer formally designates the rays by the letter *n*. This was subsequently changed to N.

Thus far the only known effect of the new rays was the brightening of a small spark. Blondlot now found that they made a small blue gas flame more luminous and white. He recommends examining the blurred image of the flame cast on a sheet of ground glass. A third effect was discovered in the brightening of an already luminous calcium sulphide screen on which the N rays fall. This became the favorite means of observation. If the screed is not already luminous, the N rays do not make it so.

Blondlot ventures the opinion that his rays lie in wave-length between the shortest electromagnetic waves and the longest of Rubens.

In the following month, June, 1903, the N rays formed the subject of editorials in the Electrical World and Engineer[239] and in the Electrician of London.[243] The latter says: "It is very strange that other physicists have not taken up this pregnant subject. Their lethargy contrasts curiously with the rush made for the Roentgen rays in 1896." But three days afterwards another physicist, Sagnac,[138] did take up the subject, though from the theoretical and not from the experimental side. He discussed Blondlot's observation of four foci behind a quartz lens and concluded that three of them are merely maxima due to diffraction of waves of length 0.2 mm. It is to be noted that this, the first criticism of Blondlot's results, is from the pen of a fellow-

countryman. Sagnac, however, utters no doubt concerning the actual existence of the rays he discusses.

In the issue of Comptes Rendus containing Sagnac's article, Blondlot[30] announces that there are N rays in sun-light. They appear to have the same properties as those from other sources.

In July, 1903, but one paper on the N rays appeared. In this Blondlot[31] states that when platinum is heated to a dark red by the electric current or by a flame, it is made brighter by focussing upon it a beam of N rays. Sensitive tests showed no rise of temperature caused by these rays. This was confirmed by Rubens also. Hot platinum was found to transmit the rays.

At the *Versammlung deutscher Naturforscher und Ärzte* in Cassel in Sept., 1903,[195] Kaufmann of Bonn, Donath of Berlin, Classen of Hamburg, with Rubens and Drude, all acknowledged failure in their endeavors to repeat Blondlot's experiments. The testimony of Rubens was especially significant because he had received from Blondlot advice as to experimental arrangements.

November, 1903.—After a long silence Blondlot[32] resumed the publication of his investigations. A band of white paper, faintly illuminated, was found to appear brighter and to have sharper outlines when a beam of N rays fell upon it. When an illuminated slit was seen reflected from a polished knitting needle, upon which N rays fell, the image darkened and turned reddish when the rays were cut off. A bronze mirror acted in the same way. When N rays fall normally upon a polished quartz surface they have no influence upon light reflected at any angle of incidence from the same surface. N rays coming through quartz affect the image formed by reflection at the surface through which they emerge.

There seems to be no action of the N rays on refracted light. The Nernst lamp without a glass globe is given as a source of strong N rays.

A week later Blondlot[33] announced that many substances after having been exposed to N rays will themselves emit this radiation for some time. This storage effect resides in the mass and not merely on the surface.

In his last paper for this month[34] he states that N rays reaching the eye from any direction increase the brightness and sharpness of outline of feebly illuminated surfaces. Since water had been found to be opaque to N rays it excited his surprise that they

could traverse the liquids of the eye. Since these liquids contain dissolved salts the reason became clear, when experiment showed that the addition of a small quantity of salt to water caused it to transmit the rays. Salt water also stores the rays. Similarly the eye of a steer proved transparent to them and showed the storage effect.

December, 1903.—Acting upon a suggestion taken from the researches of Charpentier, as yet unpublished, Blondlot[36] made the discovery that wood, glass, caoutchouc, etc., while compressed emit N rays. If an observer, looking at a barely visible white clock face in a darkened room, bends a cane before his eyes, he sees the dial become white, only to darken again when the cane is released. Such observations led to trying whether bodies in a permanent state of molecular strain do not also send out the rays. Prince Rupert drops, tempered steel, hammered brass, melted sulphur with crystalline structure, all proved to be spontaneous and permanent sources of the emission. A file or a pocket knife caused the calcium sulphide screen to light up. A steel tool was active when tempered, but was without effect when the temper was removed. A knife from a grave of the time of the Merovingians emitted the rays even after a dozen centuries of existence. Permanently deforming metals causes an emission of the N rays for a few minutes at most. Torsion produces the same effect as compression.

On Dec. 14, 1903, the first paper by Augustin Charpentier[64] appeared. He has published more papers than Blondlot himself upon the subject under consideration. He was the discoverer of the physiological rays. The La Craze prize in physiology was awarded to him in 1901 by the Academy of Sciences in Paris, to the Comptes Rendus of which body he contributed more than fifty papers.

In this paper Charpentier[64] announces the startling discovery that a barium platino-cyanide screen, made luminous by radium, grows brighter when brought near to the human body, especially to a nerve or nerve center in activity or to a contracted muscle. The course of a superficial nerve could be traced by means of the screen, and the outlines of the heart were obtained. Aluminium, paper and glass transmitted the rays. They are reflected and refracted, real foci being formed by a glass lens. It seemed that a

new method for physiological examination had been brought to light.

In a paper two weeks later Charpentier[65] claims that hares and frogs emit his rays. The possibility of explaining the effect on the screen by the action of heat was excluded in the case of the frog whose temperature was below that of the screen. In another trial the screen was heated above the temperature of the body and yet the brightening occurred.

Tendons stretched by the muscles gave no effect. Pressing a nerve increases its effect on the screen. Nerves, and especially nerve centers, are better radiators than muscles.

N rays in sun light cause a glow worm and phosphorescent bacilli to grow brighter. When a person speaks a screen held near the center of articulate language in the brain lights up. Mental effort was thought to affect the screen.

In a paper in Paris, C.—R. soc. biol., for Christmas, Charpentier[83] recounts about the same results as those given previously in his first paper of this month and in his second in Paris, C.—R. Acad. sci. This marks the appearance of the physiological rays in this periodical, in which altogether about a score of papers bearing on the subject appeared. Most of them are practically the same in content as other papers by the same authors in Paris, C.—R. Acad. sci.

On Dec. 28, 1903, Paul Audollent [227] submitted to the Academy of Sciences a claim with respect to the emission of radiation from most natural bodies of priority against Charpentier. Within a short time a similar claim was made by Köhler, Baraduc,[228] Darget,[230] Galtier,[233] Huter,[234] and others. The matter was referred to D'Arsonval[226] who reported in April, 1904, that Charpentier had not claimed to originate the idea that besides heat radiation there are other radiations from the body. The idea is in fact centuries old as is proved by the belief in the pictures of mystic painters, the fluid of magnetizers and the od of Reichenbach. Most of the claimants got their results by photography, none by the phosphorescent screen.

Dubois[231] claimed Charpentier's results to be confirmatory of results which he obtained as early as 1885, viz,—that living organisms can emit radiation capable of producing fluorescence.

S. G. Brown[146] states that he independently discovered phosphorescent zinc sulphide to brighten in the vicinity of the human

body. At first he thought it due to an unknown radiation, but further examination convinced him that heat was the cause.

At this time begins that series of papers recording failure to obtain Blondlot's results, suggesting sources of error and indicating explanations of the phenomena claimed to be observed that did not cease until the entire group of rays was discredited.

Zahn[194] tried in vain to detect the effect of the N rays by measuring the resistance of a selenium cell illuminated first by a small flame alone, and then by the flame while N rays were falling upon it. Nor could he see any difference in the flame under the two conditions.

Lummer[172] called attention to the circumstances of Blondlot's experiments,—small faintly luminous surfaces regarded in the dark,—as exactly such as would favor a shifting of the retinal image from a part of that organ where it fell upon cones to another part containing rods, with resulting change of color and luminosity, and of sharpness of outline. He records Ruben's failure to see any change of brightness.

January, 1904.—This month saw the corps of investigators in the field of the new rays increased by the addition of E. Meyer,[124] who claimed to find N rays emitted by the flowers, leaves and sprouts of plants. The effect was lessened when chloroform vapor acted on the plant. A second new worker was Macé de Lepinay[121] who announced that solids in sonorous vibration and even the air in vibration emit rays that brighten the phosphorescent screen. Lambert[116] was a third. He found N rays to appear in several cases of artificial digestion. Above each of two photographic plates an equal patch of CaS was placed. Over one was put a tube in which artificial digestion was in progress. When developed the two images were not of the same intensity.

Blondlot[37] published a memoir on the dispersion of the N rays and on their wave-lengths. A prism of aluminium gave eight refracted rays, detected by the CaS screen, of indices ranging from 1.04 to 1.85. Seven conjugate foci were found behind an aluminium lens. These last gave indices agreeing well with those obtained by using the prism.

To get the wave-lengths each of the eight refracted rays was made to fall in turn on a refraction grating and a system of fringes obtained as in the case of light. Thus wave-lengths were found ranging from .00815 μ to .0176 μ. These values were

confirmed by a study of the Newton's rings in N rays. Contrary to what holds for light waves the wave-lengths and the indices of refraction of N rays increase together. It will be noticed that the small value of the wave-lengths given in this paper is in decided contrast to Blondlot's as well as to Sagnac's[188] previous estimate.

Blondlot's method here has been severely criticized by the only two papers of importance coming from the American continent. Schenck[184] shows that some of the eight beams found behind the prism must have overlapped, and that the diffraction fringes were not to be believed in as they must have been lacking in definition. He also sharply criticizes the Newton's rings experiment.

Wood[193] noted that a beam of N rays 2 or 3 mm. wide was said to give after refraction a band only a part of a millimeter in width. When he removed the prism, it made no difference in the location of the refracted rays by the uninformed observer. When the prism was placed by Wood with its refracting edges now to one side, now to the other, in none of three trials was the observer correct in determining its position from the direction of the refracted rays.

Charpentier[66,84] resumes his work by indicating certain differences between the varieties of physiological radiation and the N rays. Neither lead nor water stops the former, while aluminium, transparent to the N rays, partly stops rays from the brain. It is however partly transparent to rays from the heart, the diaphragm and other muscles, though not to radiation from nerves. Pressure has a greater effect upon nerves than upon muscles in making the emission greater. A third difference between muscles and nerves is that the latter produce a greater effect on a warmed phosphorescent screen.

Later in the month[67] he brought out a new method of observing his rays. A small copper plate is fixed at the end of a wire of the same metal, 90 cm. long. At the other end is the phosphorescent screen. When the human body is opposite the plate the screen lights up, indicating transmission of the radiation through the wire. N rays are transmitted in the same way. This contrivance was admirably suited for investigation.

In a paper of the same date in another periodical Charpentier[98] takes up the effect of mental effort. An observer looks at a screen placed in front of the forehead of a person seated. The

latter changes his mind from rest to activity or *vice versa* without the observer's knowing it. At each change a variation of the brightness of the screen follows. Change from thought to repose causes dulling; the reverse change, brightening.

Bohn[58] uses the N rays to explain certain actions of a nereid. When the worm is in salt water, it swims while in the light but walks in the shadow. In fresh water the sensibility to light is less. This may be connected with fresh water being less transparent to the N rays than is salt water.

This month it is Swinton[186] who reports failure. He attributes the results which others obtained to physiological processes not operative in all persons.

February, 1904.—In the course of the month Blondlot published three papers. In the first [38] he describes how he registered photographically the effect of his rays in making a small spark brighter. This will be discussed at length later in this paper. In the second[39] he tells of the discovery in the radiation from a Nernst lamp of a new kind of rays, designated the N_1 rays, which lessen the brightness of a luminous phosphorescent screen. He determined the wave-lengths of three kinds of these rays by refraction through an aluminum prism and subsequent diffraction. Stretched bodies emit the N_1 rays. They are stored as are the N rays. In his third paper[40] he states that N rays increase the emission of light at right angles to a CaS screen, but lessen the tangential emission, while N_1 rays act in the opposite manner for both angles. Sonorous vibrations, the magnetic field, and an electro-motive force act as do the N rays.

Charpentier contributed five papers this month. He states[70] that the N rays increase the sensitives of vision, smell, taste and hearing.

Glass and wood were found to conduct the N rays. Transmission was effected through a wire 10.5 in. long in 13 secs. CaS is a source of N rays, when phosphorescing.[69] N rays acting upon certain portions of the skull caused an increase of brightness or of sharpness of outline. When N rays fall upon a part of the spinal column the pupil dilates.[68] The remaining two papers are of about the same content as those already quoted.[85,86]

Charpentier in conjunction with E. Meyer[100] studied the effect of inhibition upon the emission of the physiological rays.

E. Meyer[125,127] found that, even when plants are kept in the dark, they emit N rays.

The list of papers for this month shows several new names.

Bagard[1] determined the rotation of the plane of polarization of all eight wave-length of the N rays while traversing aluminium and CS_2 in a magnetic field. As was to be expected from the smallness of the wave-lengths, the effect was much larger than with light. All varieties of the N rays were completely polarized by reflection from glass.

Ballet[3] contributes a study of the emission of N rays in certain pathological cases. In paralysis there is a diminution of emission in some cases, while the opposite result was found in others. After death muscles cease to act on the screen, while nerves continue to exert their effect, gray matter being more active than white. He says he took care to avoid the effects of speaking, temperature, change of accommodation and auto-suggestion.

Bichat, dean of the Faculty of Sciences in the University of Nancy, presented three papers. He explains the transmission of N rays through a wire as due to successive internal reflections.[18] This effect he regards as similar to the passage of a beam of light along a curved jet of water.

He formed the spectrum of the N rays and then examined the absorption of each of the eight resulting rays by glass and several metals. Silver was found to be transparent to all, while palladium, nickel and iridium were opaque to all. Lead, copper, zinc, gold and glass transmit some rays and absorb others.[19] Wires of the metals were found to transmit only those rays for which they were transparent.

Liquified gases were found to emit N rays.[20] Jégou[114] detected the emission of N rays by a wire conveying an electric current. When the circuit of a Leclanché cell was closed, the liquid stored the rays and became an energetic source.

Richet[136] studied the effect of the rays emitted by phosphorescent calcium sulphide upon lactic fermentation. There seemed to be in reality an effect, but the investigator noted that other causes as well as N rays were possible.

Gutton[160,161,162,163,165] examined the effect of magnetic fields upon the phosphorescent screen. A uniform field of constant intensity had no effect, but, if the intensity changed with time or if

the field was not uniform, the screen brightened. Any action tending to set up in the screen an induced E. M. F. made it brighter. He claims to have detected the magnetic effect of convection currents by the screen. A magnet encased in lead to cut off the N rays caused faintly illuminated surfaces to appear brighter, when it was brought near the eye.

Walsham and Miller[139] in a letter to the Lancet confirm Charpentier's chief results as to rays from muscles and nerves. Moreover they got photographic results with the screen which they interpreted as showing the brightening effect. This letter is followed by a brief editorial confirmation of their results, which indeed had been expressed in the issue of the Lancet for the preceding week.[251,252]

Burke[147] reports his failure to get N ray effects. Swinton[187] now finds it easy to get some effects, so easy in fact that he is led to attribute the result to heat. Nagel[175] reported to the Berlin Ophthalmological Society his complete failure in endeavoring to repeat the experiments of Blondlot and Charpentier.

March, 1904.—Lambert resumes his work on the production of N rays by digestive ferments.[118] He also examines the N ray activity of an electric cell after the passage of the current and finds it due to chemical processes in the cell. Osmotic processes and diffusion make the screen to grow brighter.[117]

Macé de Lepinay[122] states that a CaS screen viewed normally grows brighter when sonorous vibrations are produced, while to one viewing it tangentially it appears darker. He thus confirms both his own previous observation and that of Blondlot.[40,121] This was his last contribution to the subject. Within a few months his death occurred.

Bagard[2] measured the rotation of the plane of polarization by several active substances, cane sugar, tartaric acid, etc., and found rotation in both directions to occur.

A comparison of the effects of heat and of the N rays upon the phosphorescent screen was made by Blondlot.[41]

No less than seven papers are this month due to Charpentier. He finds additional sources of rays in compressed caoutchouc, ice near zero, iodide of silver, bent ivory and celluloid, in the biceps muscle striving in vain to contract.[72,88,89] He notes a difference in the effect of an N ray source according to its condition of rest or motion. The N_1 rays diminish the sensations of

sight, hearing, smell and taste. He verified the effect of the N rays in rendering the sense of hearing more acute.[71,87,88]

When the screen rests on the fingers it lights up upon the application of an N ray source to the hand or arm or to the surface of the body. If the screen is near the heart it grows brighter when the source is applied to the pneumogastric nerve in the neck. Smell and vision are helped when the source acts on the hand. The effects of the N_1 rays are transmitted in about the same way. It appears that the nerves transmit the rays as wires do.[73,89]

The alkaloids and chloral emit considerable quantities of N rays.[74,90] Their action on the phosphorescent screen is reenforced by the presence of some other source of N rays. In this case the joint action is greater than the sum of the two separate actions. When a screen was employed consisting of a patch of CaS upon a thicker layer of alkaloid it was found that different parts of the body produced varying degrees of brightness in the screen, and that the effect of any part of the body depended upon the particular alkaloid used. That part of the body producing a maximum effect upon an alkaloid screen is the one upon which the alkaloid produces its toxic effect. For example a digitalin screen is especially bright near the heart.

Charpentier and E. Meyer extend their previous study of inhibition, finding N_1 rays also to be emitted.[101]

According to Ballet[4] the N rays can be used for diagnosis. A CS_2 screen is less bright against a sick muscle than against a well one. By the same means one kind of paralysis can be distinguished from another. He found the rays to be given off by the bodies of dogs the day after death.

The paper bearing the names of Ballet and Delherm[5] is not very different from Ballet's paper of Feb. 22, 1904.[3]

In 1900 de Hemptinne had looked for an effect of a homogeneous magnetic field upon CaS and other phosphorescing substances, but to no purpose. After the publication of Gutton's work[160,161,162,163,165] he tried the effect of non-homogeneous fields on calcium sulphide and again found no difference.[168] He modestly attributes his failure to a subjective effect, to a lack of sensitiveness of his eyes or to some peculiarity of his specimen of Ca S.

Hooker[112] wrote to the Lancet confirming the effect of vegetation in making the screen brighter.

On the other side Swinton contributes two more letters[187,188] reiterating his lack of success, and emphasizing a possible explanation by heat effects. Like de Hemptinne he fails to get Gutton's results with a magnetic field. Walsham and Miller reply to him.[140]

In answer to the various English criticisms Blondlot addressed a letter to the Electrician, London.[51] He relates that Mascart, President of the Academy of Sciences, and Cailletet came to Nancy to see his experiments. "They saw and repeated them themselves, they determined themselves the deviations of the N rays, by a prism of aluminium, and the focussing of them by an aluminium lens, they observed the fringes produced by gratings, Newton's rings, etc. They did not show the least doubt in the existence of the N rays. M. Mascart took away with him a double photograph taken in his presence or rather with his coöperation."

"A few days later I was visited by M. J. Becquerel who observed without difficulty the N rays phenomena, and who proposed in parting to follow up the study of some of them."

"I may add that I have not published one single experiment which had not been repeated by several colleagues and also by persons not acquainted with scientific research work. I have encountered but three or four persons—out of a great number—who were not able to observe the phenomena."

Rudge reported his inability to repeat Blondlot's experiments.[182] In a communication already referred to Schenck[184] of McGill University says that he obtained no certain results with the CaS screen. Differences of brightness were noticed which might have been due to

1. Decay of phosphorescence.
2. Obliquity of angle of vision.
3. Increase of sensitiveness of eye in the dark.
4. Heat effect.

It was during this month of March, 1904, that apparatus for N ray experiments was put upon the market. The manufacturer was Leslie Miller, London. He describes his apparatus in a letter to the Electrician.[133] It consisted of a hard rubber rod carrying at one end a circular box of the same material, 4 cm. in diameter. The front of this was closed by a strong plano-convex

lens with the convex side outward. On the back of the lens was a patch of Ca S about .35 cm. in diameter. In contact with this was a brass plate to which was attached a flexible wire passing out through the back of the box and ending in a small disc of metal. Upon this the N rays were supposed to fall and then to pass along the wire to the phosphorescent substance.

Several sets of this apparatus were imported into America. The advertisement in Nature spoke as follows of this apparatus: "By means of the above instrument it is guaranteed that the chief N-ray (possibly 'heat') effect, discovered by A. Charpentier, can be clearly demonstrated, including transmission by wire. The objective existence of the rays can be proved by placing the instrument on a book of any thickness, in a room so dark that an operator's arm cannot possibly be seen and asking an observer to say when the wrist is brought beneath the book." "In box with transmission wire, magnesium ribbon, etc., price £1, 1, 0."

April, 1904.—This month falls far behind all the previous months of the year in the production of N ray literature.

Charpentier[75,90] announces the discovery that, if the extract of an organ of the body be interposed between a phosphorescent screen and the organ itself, the screen is brighter than in the absence of the extract. This, he claims, will make it possible to adopt a special screen to the study of each organ.

According to Colson[102] if a Ca S screen is put near a test tube containing $Zn S O_4$ solution into which K O H solution is poured, the screen grows less luminous, indicating N_1 rays. However, if the tube contains K O H solution into which $Zn S O_4$ solution is poured, no change of the screen follows. Blondlot verified these observations. The difference of results is attributed to the formation of a basic sulphate in the first arrangement.

Still another member of the faculty of the University of Nancy joins himself to the corps of experimenters in the field of the Blondlot rays. Julien Meyer[129] finds stretched glass or copper and vacuum tubes to be sources of N_1 rays. They have greater penetrating power than N rays. They are stored, refracted and diffracted.

Munro[134a] wrote to the Lancet to suggest the study of the emission of N and N_1 rays from the body as a test of death. The accompanying editorial note indicates doubt.[253] Miller,[134] on the contrary, is confident that he can tell, by means of the

phosphorescent screen, when a man brings up his hand and stretches his muscles behind a cardboard screen in a dark room.

McKendrick and Colquhoun[173] make public their failure in striving to repeat Blondlot's experiments. They suggest heat, certain physiological actions and an attitude of expectancy as factors in the results obtained.

Hertzian waves, according to Gutton,[164] cause a Ca S screen to brighten. By this means he verified polarization and reflection. Similar effects were got with feebly illuminated ground glass.

May, 1904.—In this month the studies of Charpentier are continued by seven papers. He used the N rays to measure the wave-length of oscillations set up in the nerve of a frog by brief electrical excitation. By this method even overtones were found.[76,91] The conclusion was drawn that the vibrations are longitudinal.[77,92] The dessicated bodies of frogs continue to emit N rays for several months after death.[79]

A screen consisting of an odorous substance with Ca S was found to be especially sensitive to radiation from the olfactory centers, and a small incandescent lamp covered with black paper with a patch of the phosphorescent sulphide responded to rays from the visual centers.[78,92]

Chrome alum, according to Colson,[103] dissolving in cold water produces N rays; but dissolving rapidly in boiling water it develops N_1 rays of such strength as almost to darken the screen. Those chemical actions which cause the Blondlot rays are always attended by physical effects such as contraction, cooling, etc.

Lambert and E. Meyer[119] conclude that N rays diminish the protoplasmic activity of seed.

In the same issue of the Paris, C.—R. Acad. sci. two new workers in the N ray field appeared, André Broca[61] and Jean Becquerel,[7] the son of Henri Becquerel and a scientist of the fourth generation in his illustrious family.

The former[61] gives the details of construction of a sensitive Ca S screen, whose brightness is constantly changing when it is moved over the cranium. Along with Zimmern[63] he examined the emission from the spinal cord and obtained some apparently valuable information about the genito-spinal and vesico-spinal centers. In old people the nervous centers are less active than in the young, as judged by the effect on the screen.

By Becquerel[7] it was found that by anæsthetics such as chloro-

form and ether vapor and laughing gas the emission of N rays is suspended. After the removal of the vapor the rays are emitted once more. Previously E. Meyer[124] had observed that chloroform vapor caused plants to cease to emit N rays.

In Becquerel's next paper[8] he investigates the cause of the increased brightness of feebly illuminated surfaces under the influence of N rays. When a Ca S screen on which N rays fall is viewed through pure water it appears no brighter than without the rays. The substitution of salt water, however, causes the customary brightening to occur. This leads him to suggest that the N rays are the cause of no increase in the light emitted by the screen, but that having been absorbed by it they are again emitted and accompany the light rays to the eye whose sensitiveness they increase. The same may happen with dimly lighted paper or with a metal mirroring an object.

Blondlot[40] had found that a phosphorescent surface acted on by N rays looks brighter when the line of vision is normal to the surface, but duller when viewed tangentially. Becquerel[9] takes up this phenomenon and locates the cause in the normal emission of N rays and the tangential emission of N_1 rays, after the body has been exposed to N rays. After exposure to N_1 rays the kind of emission is reversed with respect to that just stated. He attributes the radiation of both N and N_1 rays to molecular movements existing in bodies in a state of deformation or of molecular transformation. Examining the wave-lengths determined by Blondlot he divides them into two series. The members of the first set are close multiples of 2.9 $\mu\,\mu$; for the second set 4.9 plays something of the same role.

After an interim of three months the name of Bichat[21] reappears at the head of a paper discussing fluctuations in a phosphorescent screen. These were found to be caused by many phenomena,—movements of air, convection currents, the presence of a tube of gas or of the human body. The fluctuations seem to him a delicate index of any kind of change. Chloroform vapor stops them.

In a second paper[22] he announces the results of his study of the storage of the Blondlot rays. The body under investigation was put in the path of the eight rays formed by dispersing the N rays by means of an aluminium prism. Platinium, silver and aluminium gave no secondary radiation, but copper, zinc and

glass did. The secondary radiation followed the law of Stokes in having a longer wave-length than the absorbed rays.

J. Meyer[130] found that the vapors of ether and chloroform diminish the emission of N_1 rays from stretched wire and an incandescent lamp bulb, though the vapors themselves emit the rays. It had already been noticed by E. Meyer[124] that chloroform lessened the emission from plants. With Broca Becquerel[17] examined the effects of anæsthetics on the emission of the Blondlot rays from the brain and spinal cord. At first the brain in anæsthesia emits strong N rays; later N_1 rays appear. The spinal cord shows less effect than the brain. These authors suggest the study of the rays in order to determine the danger point in the administration of anæsthetics and as an evidence of death.

It was the polarization of the N rays and their speed which were determined in his early work, Blondlot[50] now concludes, though he originally held the X rays to be concerned. "The N rays are entirely analogous to light, from which they differ only in their wave-length, which is much shorter."

On May 17, 1904, Hackett[111] read a paper in Dublin on the photometry of the N rays. Intervals of several weeks elapsed between series of his experiments and yet concordant results were obtained. As sources of N rays he used substances under strain, such as compressed wood or cork, tempered steel and unannealed glass. The increase of sharpness of outline of a diaphragm placed in front of a phosphorescent screen was the effect he employed in his experiments. When a source of N rays was brought up behind the screen the outlines of the diaphragm grew more distinct. When the source was removed, the diaphragm reverted to its former appearance. It was then shifted toward the observer until it appeared as it did when under the action of the N rays. From the distances in the two cases the percentage of increase of brightness produced by the N rays was calculated. His results were as follows,—unannealed glass, 10%; compressed cork, 9%; tuning-fork in vibration, 8%; silent tuning-fork, 3%. By this method the smallest change of brightness that could be detected was 3%.

In another method two similar phosphorescent screens with similar diaphragms wire adjusted with respect to the observer until the outlines of the two diaphragms appeared equally dim. Next one screen was subject to the N rays and the second screen

was moved nearer the eye until it again matched the first. "The observer may be ignorant of what screen is being influenced by the rays, but he will have no doubt which screen is the brighter." While confident of the effect of the N rays in making the screen brighter, Hackett failed to obtain many of the other effects.

(*To be Continued.*)

FUTURE SUPPLIES OF CONNELLSVILLE COKE.

The Connellsville *Courier* for February 7 says: The coking coal of the Connellsville and Lower Connellsville regions is practically all taken up. With the exception of a few odds and ends the Connellsville region is now all under operation, and these odds and ends are about to be cleaned up. The big purchases recently made in the Lower Connellsville region and the plans for their immediate development leave little available coal land in that region. At the present rate of consumption both these regions will be practically worked out within the next quarter of a century, if not sooner. Even the Latrobe or Upper Connellsville field and the Greensburg basin adjoining are now under active operation and will last scarcely as long as the two other fields.

The problem of a first-grade coke supply for the iron and steel trade would be serious if it were not for the fact that exhaustive tests have demonstrated that there is another big field of coking coal lying adjacent to the Lower Connellsville field, known to the trade as the Greene county field. It covers the greater portion of Greene county and extends westward almost to Wheeling. The same measures extend northward almost into Washington county for a limited distance and involve a small area of that county. Tests of the Greene county coal show it to be possessed of the same characteristics as the Lower Connellsville coal, the product of which is now classed with Connellsville coke. The Greene county field is in fact a continuation of the Lower Connellsville field westward, averaging 8 to 9 feet in thickness with a maximum thickness of 11 feet on Dunkard creek.

It is to the Greene county field that the iron and steel interests of the country are looking for their future supplies of furnace and foundry fuel. The H. C. Frick Coke Company has already purchased some 3,000 acres in Monongahela and Greene townships, and a company has taken up quite a body of coal on Muddy creek and is preparing to develop it at an early date. Several large concerns are negotiating for imperial acreages with a view of early operations. These negotiations are necessarily with J. G. Thompson, of Uniontown, who owns the larger coal area of no less than eleven townships of Greene county. His coal lies mainly east of Waynesburg and includes the larger portion of two townships west of that town. It all lies along or convenient to the proposed Uniontown and Wheeling Short Line. It is the main portion of the field and occupies largely what may be termed the basin.

GILA RIVER ALUM DEPOSITS.

Deposits of alum that present many unique characteristics occupy a small arid region in Grant County, New Mex., on both sides of the Gila River. These deposits, which have been studied and described by Mr. C. W. Hayes, of the United States Geological Survey, lie about twenty-seven miles due north of Silver City, and are at present accessible from that point by a wagon road, which reaches the Gila River at Lyons Hot Springs about six miles above, and thence follows the river down to the mouth of Alum Creek.

The alum deposits occupy a nearly circular depression below the general level of the volcanic plateau. The rocks of this topographic depression are andesitic volcanic breccias. They are the alum rock. The main mass of this alum rock occupies a nearly circular area, lying for the most part south of Gila River and west of Alum Creek. About the margins of this main mass are smaller areas occupied by the alum rock, the smallest being north of the river. Several small areas are found in the upper basin of Alum Creek. The relations of the alum rock to the adjacent basalt indicate clearly that the alum rock has broken through the basalt in the form of an igneous intrusion, probably with intense explosive violence. In every case where the contact was well exposed it was either vertical or at a high angle and the rock contained fragments of the basalt.

The most striking peculiarity of the alum rock is its extreme alteration. Careful search failed to reveal at any point within the Alum Creek basin a trace of the unaltered breccia for determination of its original character. Where exposed to leaching as in the upper parts of pinnacles and cliffs the rock is always porous, giving a hollow sound under the hammer. It is evident that a considerable part of its substance has been removed in solution.

Two forms of incrustations having entirely different chemical composition are common in association with the alum rock wherever the conditions are favorable for their accumulation. Upon the sides of the cliffs are extensive deposits of material evidently leached out of the adjacent rock and deposited from solution. These incrustations vary in thickness from a few inches to three or four feet. The outer surface has a fluted appearance resembling some stalactitic cave deposits. It is generally yellowish-white in color and is fairly hard with a porous cellular structure. Within this outer crust the material is much softer and ofter occurs as a perfectly white powder. This incrustation consists of the hydrate sulphate of aluminum, known as alunogen. The white powdery material is very pure and has practically the theoretical composition of alunogen, while the outer crust contains a slight amount of impurities and less than the theoretical amount of water.

The second form in incrustation is most abundant on the walls of the tunnels which have been driven into the alum rock. It consists of halotrichite, a silky fibrous mineral closely resembling asbestos in appearance. It has a very pale greenish color and a strongly astringent taste. The outer exposed surface of the incrustation has generally lost its fibrous structure, becoming compact and assuming a yellowish color. Although the incrustation may be several inches thick, the individual fibres are rarely

more than a third or a half of an inch in length, the crust being made up of successive layers of short crystals. Each layer probably represents the growth of a single season during which the supply of percolating water was relatively abundant. The layers of crystals are sometimes separated by a very thin film of the rock which has been split off by the growth of the subsequent layer of crystals.

The alunogen of the first incrustation is the sulphate of alumina and is free from iron, except as a minor impurity, the halotrichite of the second is the double sulphate of alumina and iron.

The value of the deposits will depend on the utilization of the soluble sulphates which they contain. The present surface accumulations of alunogen, while probably amounting to many hundreds or more probably thousands of tons, represent but an insignificant quantity compared with the sulphates still in the rock. Wherever observed the rock is highly porous, and the extent of its porosity represents the amount of material removed. In the higher and more exposed ledges the rock is thoroughly leached and will yield nothing more. At lower levels the rock still contains a part of its soluble constituents which are coming to the surface by the capillary circulation of surface waters.

Success in the development of this deposit will depend largely upon the skill with which the problem is handled. That there exists here an almost unlimited supply of aluminum sulphate appears, however, certain, and in view of the rapidly growing demand for this substance in the arts, and in sanitary engineering, and as a source of the metal, aluminum, there is little question that the supply will in time be fully utilized. The essentials for such utilization appear to be transportation facilities and chemical engineering skill. Dr. Hayes' report on this deposit will appear in the Survey's forthcoming annual "Contributions to Economic Geology, 1906."

Book Notices.

Report of the Commission Appointed to Investigate the Zinc Resources of British Columbia and the conditions affecting their exploitation. Mines Branch. Dept. of the Interior, Hon. Frank P. Oliver, M.P., Minister; Eugene Haanel, Ph.D., Supdt. of Mines. 399 pages, illustrations, plates, maps, 4to. Ottawa, Canada, Government, 1906.

The admirable scientific work which the Dominion of Canada has been doing in recent years is characterized by the broadest spirit in the selection of its agents and the greatest thoroughness in its work. Dr. Haanel was requested by the Minister of the Interior to outline the work necessary for the report, and Mr. W. R. Ingalls, Editor of the *Eng. & Min. Journ.*, of New York, was appointed chief of the staff, including Mr. P. Argall, M.E., of Denver, and Mr. A. C. Gardè, of British Columbia. The metallurgical investigation was undertaken by Mr. H. E. Wood, of Denver. The result is a valuable work of 399 pages, with a synopsis of the mining laws of British Columbia and a complete index.

The report of Mr. Argall on the zinc resources occupies 145 pages. This article gives the history, amount of production, character of ore,

market, valuation of ores, cost of smelting, value of the argentiferous blende, and wet processes of extraction in the United States; and for British Columbia the capacity, cost and methods of production, design of a zinc smelter, the works at Frank, Alberta, smelting rates on silver lead ore, preparation of zinc ores, magnetic separation, separators, plants in the Slocan, patent rights, electrostatic separation, flotation, railway transportation, electro-thermic zinc smelting, production, consumption and price; zinc mines of the Kootenays, Ainsworth Camp, the Slocan, E. Kootenay, rocks and ores of the Slocan, economic conditions, and milling in the Slocan.

Mr. Gardé reports on some mines of Ainsworth and the Slocan. Mr. Barlow reports on some undeveloped zinc deposits of British Columbia, including Vancouver Island, Texada Island, the Main Coast, and the interior of British Columbia.

Mr. Argall reports on methods for the concentration of zinc ores of British Columbia.

Henry Harris and Henry E. Wood report on the methods of assaying. Mr. Harris's flux for the silver assay was, litharge, 9 pts.; sod. bicarb., 3 pts.; borax glass, 1 pt., with a cover of salt. Three assay tons of this was used with 0.2 a. t. of the ore.

For Zn he mixed from 0.5 to 1 g. of ore with 10 cc. of water, afterwards adding 25 cc. of saturated solution of potassium chlorate in nitric acid. Evaporated and dehydrated. Added 5 g. sal ammoniac; 15 cc. ammonia, and 25 cc. water; boiled, filtered, diluted, neutralized with HCl. adding 10 cc. in excess. Titrated hot with standard sol. potas. ferro-cy., using uranium acetate as indicator.

The work is profusely illustrated by cuts, diagrams and half-tones, representing machinery, maps, scenery and ores.

It is a model of the manner of making such a report and will be a necessary reference book for the mining engineer and metallurgist.

F.

Sections.

MINING AND METALLURGICAL SECTION.—Stated meeting held Thursday, May 9th, at 8 P. M. President G. H. Clamer in the chair. Present, forty-two members and visitors.

The minutes of the stated meeting of Thursday, January 31st, were read and approved.

The president introduced the speaker of the evening, Dr. David T. Day, of the U. S. Geological Survey, who delivered an address on "The Black Sands of the Pacific Coast." The speaker illustrated his theme by the exhibition of a number of lantern slides.

Discussed by Mr. Clamer, Mr. Anderson, Dr. Ed. Goldsmith and the author.

The thanks of the meeting were voted to the speaker of the evening.

Adjourned.

WM. H. WAHL, *Secretary.*

MECHANICAL AND ENGINEERING SECTION.—Stated meeting held Thursday, May 23d, at 8 P. M. President Chas. Day in the chair. Present, 138 members and visitors.

The paper of the evening was read by Mr. James B. Bonner, of Philadelphia, on "The Present Condition of the Work on the Panama Canal." The speaker gave an account of this important work, based on personal observations made in a recent visit to the Isthmus. His remarks were profusely illustrated with the aid of lantern photographs made from pictures taken on the ground.

The thanks of the meeting were voted to the speaker for his extremely interesting address, and the session was adjourned.

KERN DODGE, *Sec'y pro tem.*

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, June 19th, 1907.)

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, June 19th, 1907.

VICE-PRESIDENT JAMES M. DODGE in the chair.

Present, thirty-five members.

Additions to membership since last report, three.

The Actuary, by instruction of the Board of Managers, transmitted a memoir on "The Speed of the Invisible Portions of the Spectrum," signed by "Algol," which had been received in competition for the Boyden Premium. With the memoir the Actuary also submitted the report of a special committee of judges, consisting of Mr. Hugo Bilgram, Prof. A. W. Goodspeed, and Dr. George Flowers Stradling, recommending that the original amount of the Boyden Premium, to wit: one thousand dollars, be awarded to the author of the memoir, Dr. Paul R. Heyl, of Philadelphia, for his successful experimental demonstration of a portion of the proposition stated by Mr. Boyden.

The Actuary likewise transmitted the following resolution adopted by the Board of Managers in reference to the subject, viz.:

"*Resolved*, That the Board of Managers hereby recommends to the Institute the approval of the report of the Judges upon certification from the Judges that they consider any further experimental demonstrations unnecessary." (A certification to this effect, signed by all the Judges, was found appended to the Judges' report.)

The following is an abstract of the applicant's thesis, prepared by the chairman of the Judges, viz.:

> "The applicant, 'Algol,' for the Boyden premium has succeeded in demonstrating, by experiment, that those of the ultra-violet rays of light for which glass is transparent, have the same velocity as the light rays proper.
>
> "He reasons that if the velocity of these rays were different they would not arrive, from a distant source, at the same time. For his

tests he selected 'Algol,' a well-known variable star in the constellation Perseus, as the source of light. By means of a diffraction grating he eliminated all but the ultra-violet rays of a known frequency, and by focusing them on a sensitive plate, obtained photographs of the star.

"For the purpose of identifying the rays so recorded with the visible rays, regarding the time of their emission, he selected, for the time of his tests, the time during which the light of this star shows the peculiar phenomenon of fading and recovering. The period of this variation is known to be about six hours. During this period he took a number of photographs, one-half hour apart, each exposure being twenty minutes, the remaining ten minutes being employed for making the necessary preparations for the next exposure. He thus obtained a number of exposures of the star on the same sensitive plate, but shifted in position. After developing the plate, the successive images plainly showed a fading and recovering, and although the exact location of the minimum brightness could not, in the nature of things, be absolutely determined, the approximate coincidence of the time of the minimum brightness of the visible and the photographed rays was obvious. These tests were repeated a number of times to eliminate the possibility of error and also to take in a certain range of the ultra-violet rays, and since favorable opportunity for making these tests is not frequent, the investigation extended over a period of two years.

"The applicant then reasoned as follows: Assuming that the photographic minimum did not exactly coincide with the observed visual minimum, their difference did certainly not exceed an hour, and since the distance of Algol is no less than forty light years, the difference of the velocities of the ultra-violet and the visual rays could not exceed one part in 250,000. This close approximation established equality to all intents and purposes."

After the reading of the foregoing abstract, the presiding officer announced the subject open for consideration.

Mr. Hugo Bilgram, chairman of the Committee of Judges, announced that he was prepared to make any explanation in reference to the work of Dr. Heyl that should be asked for.

Mr. Levy remarked that an interesting feature of Dr. Heyl's memoir was that it was a piece of original scientific research, for the neglect of which Americans have been frequently reproached.

A motion was thereupon unanimously passed confirming the award as recommended by the Judges and endorsed by the Board of Managers.

The Secretary reported the following vacancies in the Committee on Science and the Arts, viz.: Messrs. Amos P. Brown, J. Logan Fitts, C. J. Reed, Geo. P. Scholl, Frank Shuman, H. W. Spangler, A. H. Stewart, J. C. Trautwine, Jr. The following were duly nominated and elected to fill the vacancies:

Dr. G. H. Meeker in place of Prof. Brown: Chas. Zentmayer in place of Mr. Reed; Robert Job in place of Dr. Scholl; Carl G. Barth in place of Prof. Spangler; Richard Zeckwer in place of Dr. Stewart; Luther D. Lovekin in place of Mr. Fitts; Joseph H. Burroughs in place of Mr. Shuman; Mr. Henrick V. Loss, in place of Mr. Trautwine.

The following communications were presented:

The Holophane System of Illumination, by Mr. A. J. Marshall, Illuminating Engineer of the Holophane Glass Co., New York.

Asbestos Fireproof Materials for Buildings (flooring, siding, shingles, etc.), made by Keasby & Mattison, of Ambler, Penna. The subject was presented by Mr. Weldon Clark, the local representative of the manufacturers.

An improved Draughting Board was exhibited and described by Mr. Jos. W. Bramwell, of Philadelphia.

The subjects of the last two communications were referred to the Committee on Science and the Arts, and the thanks of the meeting were voted to the several speakers.

Adjourned.

LOUIS E. LEVY, *Sec'y pro tem.*

Committee on Science and the Arts.

(*Abstract of proceedings of stated meeting held Wednesday, June 5, 1907.*)

DR. WM. O. GRIGGS in the chair.

The following report was adopted:—

(No. 2402.) *A Re-discovered Lost Art.* Frank Della Torre, of Baltimore, Maryland.

This report was made advisory.

The following reports passed first reading:—

(No. 2392.) *Improvements in Diffraction Color Photographs.* Herbert E. Ives, of Weehawken, N. J.

(No. 2400.) *Improved Primary Battery.* Frank A. Decker, of Philadelphia, Pa.

(No. 2409.) *Diffraction Color Photographs.* Prof. R. W. Wood, of Baltimore, Md.

DEFERRED BUSINESS.—(No. 2389.) *Improved Thermometer Support.* Dr. T. F. Townsend, of Philadelphia, Pa.

A motion for reconsideration of the Committee's action in the above-named case was passed and the subject was again brought before the Committee for action. A motion to change the award from the grant of a certificate of merit to the grant of the Edward Longstreth Medal of Merit was made and upon being put to vote, was lost, by a vote of nine ayes to two nays, the remaining three members present declining to vote.

NEW BUSINESS.—The names of the following gentlemen were reported as having resigned from the committee:

Messrs. A. P. Brown, J. Logan Fitts, C. J. Reed, Geo. P. Scholl, Frank Shuman, Dr. A. H. Stewart, J. C. Trautwine, Jr., and Prof. H. W. Spangler.

A special committee, consisting of Messrs. Christie, Levy, Donaldson and the Chairman and Secretary, ex. off., was appointed to present nominations to fill these vacancies at the stated meeting of the Institute, to be held on Wednesday, the 19th inst.

Adjourned.

WM. H. WAHL, *Secretary.*

FIG. I

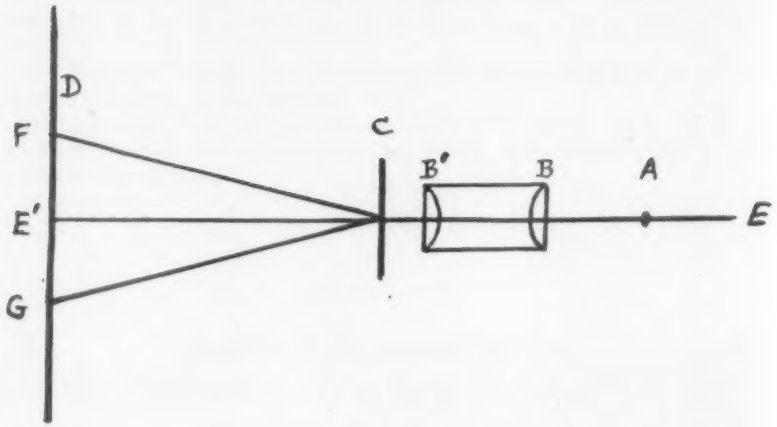

D
F
E'
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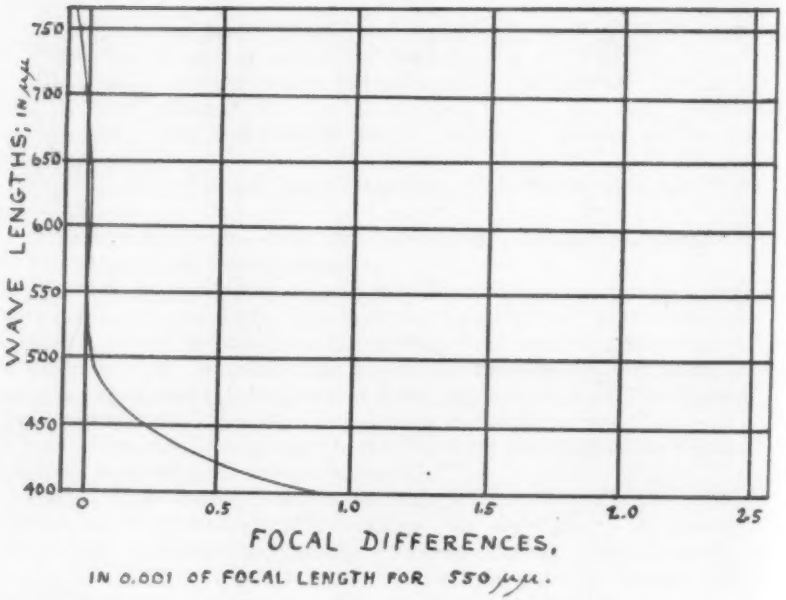
FIG. II.


WAVE LENGTHS; in μμ
750
700
650
600
550
500
450
400
0
0.5
1.0
1.5
2.0
2.5
FOCAL DIFFERENCES,
IN 0.001 OF FOCAL LENGTH FOR 550 μμ.